SCHOOL SCIENCE AND MATHEMATICS

VOL. XIII, No. 4 APRIL, 1913 WHOLE No. 105

THE EFFECTS OF ADVANCING CIVILIZATION UPON PLANTS.[1]

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In speaking of the effect of advancing civilization upon vegetation, I do not intend to deal with the deforestation and general displacement of natural floras by man-induced ones, that accompany the march of civilization. I am to speak of the injuries to vegetation, natural and cultivated, produced by poisonous materials added to the atmosphere or soil by development of industries, manufacturies and other processes going hand in hand with advancing civilization.

After dealing with the general field of the subject in the way of a few summary statements and a few illustrations, I shall turn to a special phase that has been developed by a group of workers[2] at the Hull Botanical Laboratory.

The facts I am to present among other things especially emphasize two matters of importance: that many plants are extremely sensitive to injurious agents—a sensitivity undoubtedly equalling if not exceeding that of animals—and that we have in this field a source of economic loss to which we, in the United States, are becoming only slowly conscious.

Germany was one of the first to realize the great injury to vegetation caused by poisons added to the air and soil in this way. Several causes attribute to this early awakening on the part of Germany; of all the powerful nations, Germany stands pre-eminent in putting every phase of production on a scientific basis; in Germany it is common to have large industries in the midst of the agricultural districts; and limited in the way of natural resources and resulting raw materials, a considerable loss of any of them could not long be endured. I cannot go into detail on the

[1] Paper read before the biological section of the Central Association of Science and Mathematics Teachers, Evanston, Illinois, Nov. 29, 1912.
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extensive literature on this subject in the German language. Suffice it to say that almost every industry—tile, brick, glass, cement, smelter, steel, iron, and a score of others—gives off its plant poisons. In some cases these injurious products have been caught with economic gain as by-products of the industry.

Now let us turn to a few illustrations drawn from recent literature upon this subject. A portion of a recent general study of the smoke problem of Leeds, England, deals ably with the injuries to vegetation from this source. The plants more sensitive to smoke injuries, such as the conifers, have been entirely driven from the city. It was found that these forms could not persist where the total soot fall was 200 lbs. or more per acre per annum, whereas the soot fall in the more central regions was as great as 1,565 lbs. per acre per annum. Plants that could persist in the face of the smoke nuisance were greatly stunted; the yield of lettuce in the more smoky regions was less than one-fourth that of remote residential districts. These injuries are attributed to four main causes: reduction of light intensity, often by 60%, due to the pall of smoke; collecting of tar on leaves still more reducing available light and closing stomata against gas exchanges; absorption of poisonous gases, especially sulphur dioxide, by the leaves; and destruction of soil organisms necessary to fertility by the accumulation of sulphurous and sulphuric acids in the soil. These troubles are such as every manufacturing city must meet. Even a casual observer can see the passing of the conifers in progress in the city of Chicago anywhere within a radius of six miles of the business center of the city.

Various French investigators have shown that tar used in tar macadam boulevards produces great injury to neighboring vegetation. This injury appears only in case the boulevard is much traveled and the climate is very warm. The injury seems to come about by the fine tar dust falling on the leaves and then being distilled so the toxic distillates enter the stomates, thereby producing the injury. Although this cause has actually denuded the much traveled boulevards of Paris the injury develops slowly and the death of the trees does not occur until two or three years after the construction of the roads. The early injury is marked by a great reduction in the size and number of leaves and by a very early leaf fall. Death is believed to be a matter of slow starvation due to reduced synthetic power. Among the more sensitive trees are Catalpa, various maples, box elder, sycamore, linden, walnut and the Kentucky coffee tree and among the more

resistant plantain, elm and Sophora. These injuries are not limited to trees and shrubs, but are evident with various herbaceous plants used in the parking beds. Pelargonium lierre, P. divers and others are very sensitive while various zinnias, pinks, and others are resistant. There are a number of reports of the complete destruction of vegetables in truck gardens along much traveled tarred roads of Southern Europe. Gatin, one of the French workers, points out the fact that no such injuries have been reported from England or the United States and attributes this to two conditions: less intense summer heat and the use of redistilled tars in the countries mentioned. In redistilling the coal tar from the gas industry, three or more fractions of distillates are caught. In many cases one of these fractions—anthracene—transformed to alizarine for the dye industry, is worth more than both the gas and the raw tar. This is saying nothing of the valuable benzol, phenol, and other fractions. In short, redistillation, which, if Gatin is correct, renders the tar less noxious to vegetation, is an extremely profitable business. The profit in redistillation will more than likely rise tremendously with the rapid advances that are now being made in the study of coal tar products. The lack of reported injuries in the United States cannot in great part be due to the redistillation of tars, for I see by Literary Digest that less than 20% of American tars are redistilled in contrast to 90% in Germany. It is more probably due to the greater use of asphalt and to the lack of keenness on the part of American foresters in tracing injuries to the real cause. Gatin flatters us by overestimating the efficiency of our industries and by assuming that they are on scientific foundations.

American scientists have been less active than Europeans in studies of injuries to vegetation by industrial wastes but considerable work has been done even in this country. Hayward has reported on the destruction of forests, other natural vegetation and crops, in the region of smelters located in various parts of the United States and Peirce now has an elaborate report under preparation covering smelter injuries. The destruction of vegetation in the region of smelters is certainly due, in the main, to sulphur dioxide and sulphur trioxide, while injury to animals comes from the arsenic compounds given off in the fumes which settle on the vegetation used as their food.

Peirce states that the stimulus given to the cement industry by the rebuilding of San Francisco has led to the construction of cement plants in various productive valleys of California. Ce-

ment dust in the wake of prevailing winds is destroying or rendering unmarketable great quantities of fruit and other agricultural products. Parish has also reported similar injuries to citrus fruits. The fact that cement plants are generally located in rural regions leads to large losses from this source.

A group of scientists are at work studying the destruction in the region of Pittsburg brought about by the gas and soot ladened atmosphere of that industrial city.

II. Effects of Illuminating Gas.

After these few general statements, and illustrations, we will turn to a series of experiments performed at the Hull Botanical Laboratory on the effect of illuminating gas and other dry distillation products of carbon compounds upon plants. There are numerous reports from Germany, United States and other countries of the destruction of trees in parks and parkings by illuminating gas escaping from leaking mains. Stone has shown that in case soil of a loose texture has a frozen crust, gas from a leak may diffuse laterally as far as 2,000 feet in sufficient quantities to be detected by odor.

About four years ago we began receiving numerous inquiries about the effect of traces of illuminating gas upon the flowers of carnations and other plants. Greenhouse operators claimed that gas had diffused from leaking mains laterally through the ground and up into their greenhouses. The injuries were alleged to occur at periods of intense cold which favored lateral diffusion because of the frozen crust and prevented any considerable ventilation of the greenhouses. A recovery of the stock of the greenhouse always followed the repair of the mains.

As is well known, illuminating gas, whether water, coal, or oil gas, is a mixture of a number of gases and vapors. Carbon monoxide, hydrogen methane, ethylene, acetylene, and the higher homologues of the last three make up the greater part of the gas. Our experiments show the *flower* of the carnation remarkably sensitive to illuminating gas and certain of its constituents while the foliage is relatively resistant. If a bud just beginning to show its petals is subjected to 1 part of illuminating gas to 20,000 of air for three days, the petals cease developing, while the stigmas continue their growth and there results the form shown in Fig. 1, a. Such a bud developes no farther even if removed to pure air but soon withers. If a similar bud is subjected for the same time to 1 part of gas in 40,000 of air the petals continue to grow but

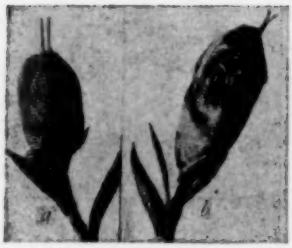

FIG. 1.—a, result of treating a bud, just beginning to show the petals, for three days with 1 part of illuminating gas in 20,000; b, result of the treatment of a similar bud, for the same length of time, with 1 part of ethylene in 500,000.

FIG. 2.—Result of treating a bud, just beginning to show the petals, for three days with 1 part of ethylene in 1,000,000.

never open and a form like that shown in Fig. 2 results. Very young buds are as sensitive as old ones but medium aged ones are much more resistant. Open flowers are even more sensitive than buds to traces of the gas. They go to sleep, as the florist would say, after 12 hours' exposure to as slight a trace of illuminating gas as 1 part in 120,000 of air. Fig. 3, d, shows the sleep pro-

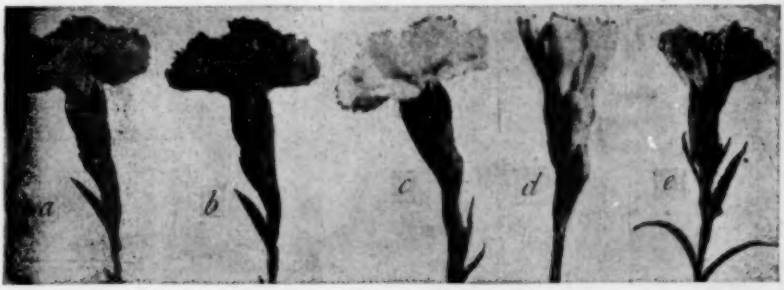

FIG. 3.—(a) a flower that has just opened; (b) the same after being corked in a 20-liter flask of air for 24 hours; (c) a flower that has just opened; (d) the same after being exposed 12 hours to 1 part of illuminating gas in 40,000; (e) result of treating a flower that just opened for 12 hours with 1 part of ethylene in 2,000,000.

duced in a freshly opened carnation after 12 hours' exposure to 1 part of gas in 40,000 of air. As marked results are obtained by 1 part gas to 80,000 of air and decided sleep is produced by 1 part in 120,000.

What constituents determine the toxic limit of illuminating gas on the flower of the carnation? Without giving the evidence in any great detail, I will say that our experiments almost certainly show that the contained ethylene determines this extreme toxicity. In the smallest trace of illuminating gas that is injurious to these flowers no other known constituent exists in 1/50 sufficient concentration to produce the effect. When a bud just showing its petals is placed for three days in an atmosphere containing 1 part ethylene in 500,000 of air the petals cease to grow while the stigmas project and there results the form shown in Fig. 1, b. This is almost exactly the result received from 1 part of illuminating gas in 20,000 of air. Ethylene, here, is about 25 times as toxic as illuminating gas. It exists in gas as a 4% constituent and probably determines its limit of toxicity. The freshly opened flower when subjected for 12 hours to 1 part of ethylene in 2,000,000 of air goes to sleep as shown in Fig. 3, e. This so-called sleep is an irreversible reaction and is the first step in withering of the flower from whatever cause.

These experiments explain the generally observed short life of cut carnations in dwellings lighted with gas. Furthermore, all the responses studied here tally with those observed in city greenhouses showing injury from illuminating gas. The extreme sensitiveness shown probably explains why it is that such greenhouse injuries continue for three or four years before the source of injury is finally located by the odor of gas. It must be remembered that injuries are not limited to the carnation, but appear in many other forms as flower or foliar response—fall of petals or leaves, epinastic movements of leaves, or development of lenticular lesions in the tissues. Even in individual greenhouse systems of not very pretentious size the aggregate loss of an experience of this sort reaches $20,000.00 or more. While the total annual loss in United States must run very high. Stone states that only 90% of the illuminating gas manufactured by utility companies in the State of Massachusetts in 1905 was recorded by the consumers' meters. Stone assumes that a part of this may be accounted for by a temperature-volume change, though probably not a very large part of it. Since we do not care to do the views of all consumers violence by assuming that gas meters generally record too slowly, we will believe that a large part of the 10% escaped into the soil through leaking conduits. The judicious application of 10% of the gas manufactured in the United States should destroy a number of trees and leave some over for putting carnations to sleep.

In connection with the poisoning of human beings there have been extensive chemical studies for the purpose of developing delicate methods for detecting traces of illuminating gas on the basis of the contained carbon monoxide. The most delicate methods yet devised will detect 1 part of carbon monoxide in 40,000 of air, or since illuminating gas is about 25% carbon monoxide, 1 part of illuminating gas in 10,000 of air. As we have seen the carnation responds by closing to 1 part of illuminating gas in 120,000 of air. It is approximately twelve times as sensitive to illuminating gas as the most delicate chemical test. The sensitiveness is still more striking if we remember that carnations respond to ethylene, approximately a 4% constituent of the gas, while the chemical method detects carbon monoxide, a 25% constituent of the gas. As a means of detecting ethylene this seedling is from 2,000 to 5,000 times as sensitive as chemical methods. In the light of these facts it is not strange that chemical tests have failed to show any carbon monoxide in greenhouses where illuminating gas is doing marked injury.

With chemical methods precluded as a means of detecting the least trace of gas that will injure carnations and other flowers, we turned our search in the direction of very sensitive plant organs that give characteristic responses. German workers have observed that the etiolated epicotyl of pea and other legume seedlings have a very characteristic method of growth in laboratory or "impure" air.

In order to find a highly sensitive form as a test plant we studied the response in 20 varieties of garden peas and 20 varieties of sweet peas. The sweet peas in general proved much the more sensitive. One of these, the Earl Cromer, was especially re-

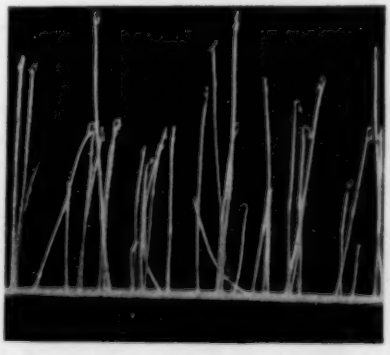

FIG. 4.—Etiolated epicotyl of Earl Cromer grown 1 week in pure air.

sponsive. Fig. 4 shows the tall, slim, straight, etiolated epicotyls of Earl Cromer grown for one week in pure air. Fig. 5, a and b, show the typical response of the seedling to "impure" air. The response here is three-fold: reduction of rate of elongation, transformation of negative into diageotropism and increased growth in diameter. It is very necessary that the experiment be

FIG. 5.—(a) Etiolated epicotyl of Earl Cromer grown for 4 days in pure air followed by 3 days in 20 p. p. m. of illuminating gas in air; (b) Same as (a) except the last three days in .8 p. p. m. of ethylene in air.

carried out in total darkness for light even of low intensity, greatly reduces the sensitiveness of the seedlings. Our work has made it seem very probable that illuminating gas is the effective impurity in laboratory air and that ethylene is the only constituent in sufficient concentration to produce the reaction. A series of figures here will show the parallel between the effect of illuminating gas and ethylene. Fig. 4 shows etiolated seedlings of Earl Cromer grown in pure air for 1 week. Fig. 5, a, shows etiolated seedlings of Earl Cromer placed for the last 3 days of the week in 20 p. p. m.[1] of illuminating gas in air. Fig. 5, b, shows similar seedlings placed for the last 3 days of the week in .8 p. p. m. of ethylene in air. The degree of response is similar in the two cases, showing ethylene 25 times as effective as illuminating gas. Fig. 6, a, 10 p. p. m. of illuminating gas in air. Fig. 6, b, .4 p. p. m. of ethylene in air. The degree of response is similar in these

FIG. 6.—(a) Etiolated epicotyl of Earl Cromer grown for 4 days in pure air followed by three days in 10 p. p. m. of illuminating gas in air; (b) Same as (a) except the last 3 days in .4 p. p. m. of ethylene in air.

[1] p. p. m. means: parts per million.

two cases, again showing ethylene about 25 times as effective as illuminating gas. These figures show what all the evidence in our work indicates, that ethylene which is approximately a 4% constituent of the gas determines its effectiveness in producing the triple response of legume seedlings. Finally, the extreme sensitiveness of the seedlings to ethylene is shown in Fig. 7: to the right are the controls and to the left those in .1 p. p. m. of

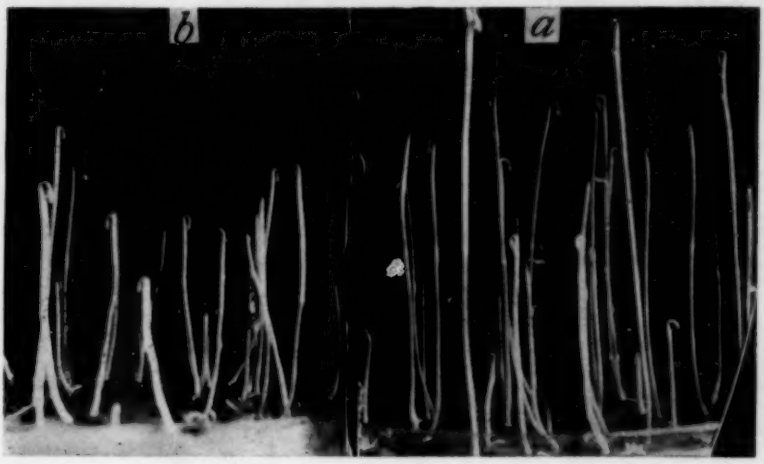

FIG. 7.—(a) Etiolated seedling of Earl Cromer grown for one week in pure air. (b) Similar seedling grown for the last three days of the week in .1 p. p. m. ethylene in air.

ethylene in air. Although this slight concentration is not sufficient to produce either an increase in thickness or diageotropism still it brings about a very evident reduction in the rate of elongation. So far as I know there is not another case reported that approaches this for sensitiveness to atmospheric impurities.

How specific is the reaction of these delicate test seedlings for illuminating gas or the contained ethylene. We have studied the effects of more that 50 gases and vapors upon these seedlings, including possible laboratory impurities, paint solvents, coal tar products and the main constituents of illuminating gas. Although some of the gases and vapors, among them carbon monoxide, propylene and acetylene, produce the triple response, in every case there must be a sufficient quantity to be easily detected by other means. Furthermore if illuminating gas were present in sufficient amount to make carbon monoxide or any of the constituents an effective agent ethylene would be sufficiently concentrated to produce death very quickly. A number of substances, ether, chloroform and others, produce only a double response,

reduced rate of elongation and increased thickness. A third group including alcohol, pyridine, ammonia, and hydrogen chloride, give only reduction in rate of elongation but neither increased growth in thickness nor diageotropism.

Several German workers have assumed that the triple response, as I have termed it, is a general response to all toxic agents. It is quite evident however that the matter is not so simple but that there are three distinct types of responses to the various groups of reagents.

The injury of potted plants by illuminating gas in dwellings and greenhouses is probably entirely through the aerial parts while the injury to trees in the open is mainly through the roots. We find that these delicate seedlings can be used as a means of locating with accuracy this source of injury in each case. The method for determining aerial injury is simple, involving few precautions, as what is already stated indicates. The detection of the gas in the soil is more complex involving two important physical facts: (*a*) gas and other substances are readily absorbed and tenaceously held by soils; (*b*) gases though absorbed can be largely withdrawn from the soil by the application of low pressure and moderate heat. To run this test, seedlings are grown in the gas thus withdrawn and their response observed. It is interesting in this connection that the odor producing constituents of illuminating gas, certainly far less toxic to plants, are much more fully absorbed than ethylene so they can be detected in the withdrawn atmosphere even when there is no response of the seedlings.

III. Effect of Tobacco Smoke.

Molisch, a German plant physiologist, has lately reported on a large number of experiments showing the extreme toxicity of tobacco smoke to plants. The forms studied were many, ranging from the bacteria to the highest angiosperms.

As Molisch puts it, one whiff of cigar or cigarette smoke blown over a culture of phosphorescing bacteria puts them out in 30 seconds. They again recover their power to phosphoresce if placed in fresh sea water. Chromatium, Beggiatoa and various species of Spirillum were highly sensitive although less so than the phosphorescing bacteria. Certain protozoans studied: Amoeba, Vorticella, and Paramoecium, were very readily killed by traces of the smoke. Seedlings of legumes were likewise very sensitive. Three whiffs of cigar or cigarette smoke in a

four or five liter container bearing such seedlings gave a response similar to those we have shown for illuminating gas. Like quantities of tobacco smoke in 4 to 7 liter containers bearing various sorts of mature flowering plants showed rather characteristic responses. In some epinastic movements of the leaves occurred, in others leaf fall and in the soft tissue of many the formation of lenticular lesions.

The "whiff" of Molisch as a unit of measure dignifies the cupful, teaspoonful, and thimbleful of the ladies to the very acme of accuracy. Some of the readers will question the innocuity of the breath of a German scientist. To this it must be replied that German beer bears a very low per cent of alcohol and further that Molisch receives like response if he burns a piece of the best linen paper in the container bearing the plants.

In short, the high toxicity of tobacco smoke to plants cannot be attributed to nicotine or other compounds peculiar to tobacco but to certain dry or destructive distillation products formed in the burning of any carbon, hydrogen and oxygen containing, compound of whatever complexity. The matter becomes clear when we remember that the burning of wood, paper or any other similar substance involves two distinct and successive processes. The first process is one of dry or destructive distillation which forms various reduced carbon bearing gases, the more abundant of which are carbon monoxide, acetylene, ethylene and methane. This step is not very unlike the manufacture of illuminating gas. The second process is the oxidation of the reduced gases to carbon dioxide and water. Even under the most favorable conditions for burning, traces of these gases probably escape complete oxidation. In light of this it is safe to say that every coal and wood fire is adding to the atmosphere its trace of noxious carbon gases.

What constituents of the tobacco or paper smoke determine their great toxicity? Molisch has concluded probably wrongly, as one might expect from his "whiff" methods, that carbon monoxide is the highly toxic constituent of the smoke. Our extensive studies on the sensitive test seedlings have shown that ethylene has a very much higher magnitude of toxicity than acetylene, carbon monoxide and methane. As a matter of approximation we may say if we let 1 represent the toxicity of methane, 20-40 represents the toxicity of carbon monoxide, 200-400 that of acetylene and 200,000-500,000 that of ethylene. This alone renders it highly probable that ethylene which is known to exist in tobacco smoke and other smokes from burning carbon

compounds is the toxic material. A long series of experiments run by us on smoke of cigars, cigarettes and linen paper cigarettes shows it is not the carbon monoxide that determines the limit of toxicity. To the disgust of our tobacco using friends we had a machine to do the smoking. The smoke was washed free from all tars, ash, nicotine, sulphur oxides, carbon dioxide and ammonia and only the clear colorless gas used. A long series of experiments on the washed smoke from pure linen (cellulose) paper cigarettes showed the smoke about 10 times as toxic as carbon monoxide. Fig. 8, a, shows the effect of 2 per cent carbon monoxide in the air during the last three days of the culture. Figure 8, b, shows the effect of .2 per cent linen paper cigarette smoke for

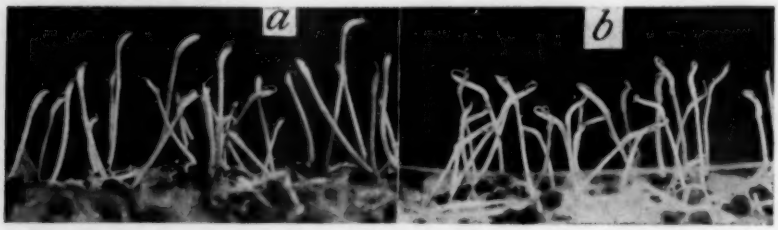

FIG. 8.—(a) 2% CO during last 3 days of culture; (b) .2% paper cigarette smoke during last 3 days of the culture.

the same time on similar seedlings. The following pairs showed about equal responses; .1 per cent paper smoke and 1 per cent carbon monoxide; .05 per cent paper smoke and .5 per cent carbon monoxide; .025 paper smoke and .25 per cent carbon monoxide. From analyses that have been done on the gases of the main stream of cigar, cigarette, and pipe smoke it is safe to assume that at least 85 per cent of the smoke used above is nitrogen and oxygen and certainly not over 10 per cent of it is carbon monoxide. In short there is not more than $\frac{1}{100}$ enough carbon monoxide to produce the effect noticed in the cultures. Likewise there is not enough acetylene or methane to give the response. It leaves this trace of the highly toxic ethylene as the effective gas. It is interesting that the smoke from linen paper cigarettes was always more toxic than that from cigars or tobacco cigarettes. This is probably due to the fact that paper cigarettes were more tightly rolled and therefore less well supplied with oxygen in the smoking. This increased the percentage of dry distillation gases.

IV. SUMMARY.

Ethylene then seems to be the predominantly toxic constituent of destructive distillation products of carbon compounds so far

as the test seedling and the carnation flower is concerned. Work in our laboratory also indicates that this holds for the root of the Windsor bean. How generally it will show such a relatively high magnitude of toxicity throughout the plant kingdom one cannot say.

It has been assumed that the main gases in coal smoke of our cities that played a role in the plant injuries are sulphur dioxide and sulphur trioxide. These data however indicate that the workers have probably been neglecting another group of very toxic gases existing, it is true, in small quantities but considering their extreme toxicity perhaps in sufficient quantities to produce injuries—the dry distillation gases from the carbon compounds—especially ethylene.

The few facts established in this field suggest the need of rationalizing various practices in vogue and summarily abolishing others. Take, for instance, the practice of burning tobacco stems in greenhouses for killing insects. This is a matter of differential poisoning—applying a poison that will kill the insect without injuring the plants. The process volatilizes nicotine and sets free carbon dioxide, carbon monoxide, ethylene, and other gases. So far as I know it is not certain which is the insecticide. If it is nicotine, why not volatilize nicotine from an extract and avoid the deadly plant poison ethylene; if it is carbon monoxide why not generate it chemically and thereby avoid ethylene! Again it is a rather common practice to have the heating furnace in more or less open connection with the green houses. If one recognizes the probability of the dry distillation gases escaping from a furnace along with the extreme toxicity of ethylene, he can see the need of abolishing this practice.

In conclusion let us mention that the extreme sensitiveness of plants to atmospheric poisons reminds the student of plant response of the care that must be taken in this direction. We are coming to realize that impurities of laboratory air have viciated the results and conclusions of a number of pieces of plant physiological work. No doubt like caution should be heeded by animal workers. Again in industrial poisons we have a source of enormous economic loss. In America the loss in the main involves decorative rather than economic plants and the cost of replacement probably aggregates far above the loss from any one of the most destructive plant diseases. In many cases we need methods for detecting the exact source of injury on one hand and more scientific industrial methods for preventing them on the other.

A STUDY OF AN ATTEMPT AT UNIFORMITY IN GRADING STUDENTS.

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In the spring term of 1910 a committee of the faculty was appointed at the Northern State Normal School of Michigan to study the matter of the marks given by the various instructors during several terms with the view of finding out what degree of uniformity there was in the various departments in grading the students. The report of this committee covered grades given by the instructors in the normal school during a period of three years—1908-1910, inclusive. These data, set forth in the report, are given in the first division of the tabulation printed herewith, except that only those faculty members are herein included who were in residence at least six terms during that period. The figures show for each instructor marks given in each grade, A, B, C, etc., expressed in percentages of his total marks. For convenience in designation, the faculty members are numbered 1 to 12. The value of the grades, approximately expressed in per cent, is as follows: A, from 90 to 100; B, from 80 to 89; C, from 70 to 79; D, from 60 to 69; and E, under 60 per cent. E was the failing mark and D was then a "condition" necessitating a second examination.

It needed little study of the tabulation when the report was presented to show that there was rank irregularity in the marks given by various instructors. Compare, for instance, the percentages for numbers 1, 4, 6 and 11. This inequality is even more apparent when the data of the tabulation are thrown into the form of curves, easily comparable (see figure). It is to be noted that all the faculty members were dealing with the same sort of students. The student body was remarkably homogeneous, consisting almost entirely of high school graduates drawn from the cities of the upper peninsula, all pursuing the same general course. It was patent at once that either no common standard of values existed for the grades given or else that the class work of the several instructors varied greatly in its difficulty.

The report of the committee gave rise immediately to legislation in substance as follows. All instructors are expected to have the distribution of their grades follow approximately the curve of probabilities, not for any single class or any term, but in a period of two years. The normal distribution is taken as

A, 2 per cent, B, 23 per cent, C, 50 per cent, D, 23 per cent, and E, 2 per cent. The per cent of marks given by each instructor in each grade shall be reported for every term in open faculty meeting. Students securing an A will be given 25 per cent added credit; B, 15 per cent added credit. Students securing a D receive only 60 per cent, of a full credit. C is considered the mark of average accomplishment, E, a total failure with no credit. Plus and minus signs (B+, B—, etc.) to indicate shades of difference are abolished.

The result of the legislation is in part given for four succeeding terms and shows very clearly the attempt of the faculty

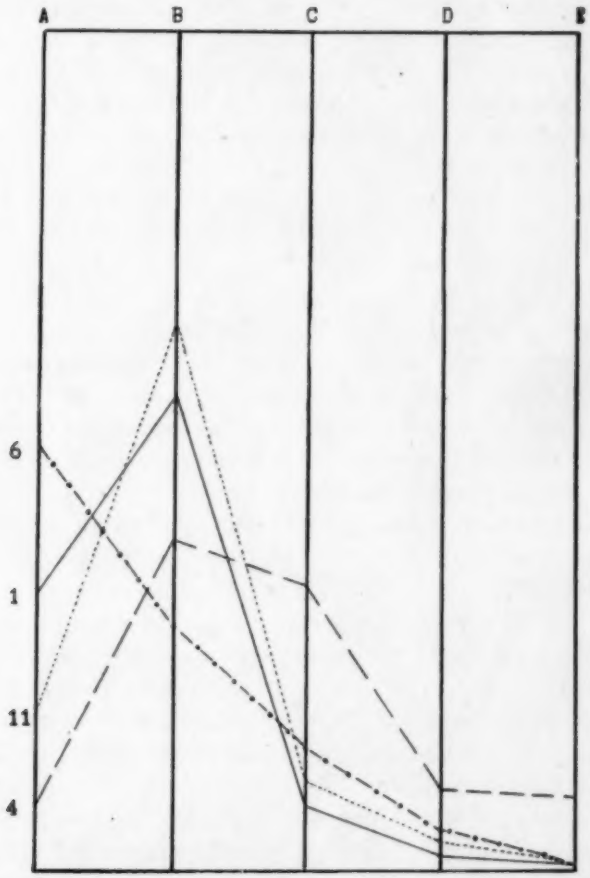


TABLE SHOWING GRADES OF FOUR INSTRUCTORS, NOS. 1, 4, 6, 11, DURING 1908-1910 INCLUSIVE. THE ENTIRE HEIGHT OF THE FIGURE REPRESENTS 100%.

members to reach a more nearly uniform standard of excellence. This study is of general interest because it shows in a specific instance how the adoption of a scheme of grading may help to establish norms of work and standards for grades. It is very evident that if instructor number 1 is just to the students in giving only 13 per cent of them C or less, number 9 is unjust in giving 53 per cent of the same student body C or less, or else the work given by number 1 is much easier than that given by number 9. In practice it seems relatively simple to discover which case accounts for the discrepancies. In the discussion which followed the report of the committee, instructors stated that their standards of fair work were different, some having considered that B stood for fair work, others C+, and a few even A—. This difficulty was adjusted promptly by designating C for average work. The effect of this single bit of legislation is apparent at once. With an understanding of the evaluation to be put upon fair work, the grades are immediately much more nearly homogeneous as is evident from the tabulation of the grades of the fall term of 1910. The differences which still appear, at least where reasonably large numbers of students are concerned, are to be interpreted possibly as due to inequality of the grade of class work demanded. Remarks dropped during faculty discussions, while the attempted readjustment was in progress showed appreciation of these successive difficulties, and the conscious attempt to accept C as the grade of fair accomplishment, and second to alter the character of the work so as to conform to the standard of general usage.

I am inclined to think that the study of the grades in almost any school system would show that the inequality of the marks given by various instructors is usually fully as great as is apparent in this case in the years 1908-1910. I see no simpler way to establish some standard of accomplishment in class work than the adoption of such a scheme of marking. It certainly must fairly promptly bring out the fact that some instructors are making their work unusually difficult, while some are giving work that is too easy for the grade of students handled, if such facts exist. The reason assigned for dropping plus and minus signs to indicate shades of difference was that where a large number of grades are possible there is apparent in this case a tendency to use only the higher grades. The author is unable to report the effect of legislation regarding the added or subtracted credits as he is no longer connected with the institution.

TABLE OF GRADES GIVEN BY INSTRUCTORS 1-12, NORTHERN STATE NORMAL SCHOOL.

Faculty Member	Marks given 1908 to 1910 incl.					Fall 1910						Winter 1911						Spring 1911						Fall 1911					
	A	B	C	D	E	A	B	C	D	E	No. of Students	A	B	C	D	E	No. of Students	A	B	C	D	E	No. of Students	A	B	C	D	E	No. of Students
1	33	56	8	2	1	10	25	50	11	4	28	5	27	59	5	4	22	7	29	49	15	0	31	3	25	47	25	0	41
2	41	26	21	8	4	3	28	45	20	4	68	9	34	32	14	11	44	6	26	46	17	5	81	..	..	..	..	..	..
3	21	42	27	3	7	6	24	46	14	10	63	6	27	44	12	11	90	4	29	48	15	4	48	1	22	39	30	8	79
4	8	39	34	10	9	0	35	37	25	3	31	7	20	46	20	7	29	0	22	50	21	7	58	0	26	45	24	5	62
5	23	48	17	4	8	15	31	39	11	4	71	8	41	26	21	4	91	2	35	41	17	5	95	0	23	61	10	6	47
6	50	29	15	5	1	0	28	47	18	7	43	0	34	57	9	0	35	0	52	44	4	0	25	0	24	59	7	10	29
7	17	40	32	2	9	6	34	48	9	3	54	16	23	51	7	3	61	9	30	50	9	2	67	5	21	39	30	5	43
8	17	56	24	0	3	9	20	53	11	7	45	4	26	56	12	2	54	4	20	58	4	14	50	..	..	..	..	..	..
9	12	35	41	6	6	5	25	54	8	8	24	3	40	33	17	7	30	..	..	..	..	..	..	..	..	..	..	..	..
10	24	48	24	2	2	0	35	35	12	18	17	0	50	25	13	12	16	0	50	31	13	6	16	0	6	56	0	38	16
11	19	65	11	4	1	6	22	47	23	2	62	14	35	36	14	1	55	9	24	51	14	2	53	0	31	49	16	4	51
12	27	36	24	6	7	10	36	40	7	7	27	8	27	53	4	8	52	10	20	60	5	5	63	4	16	42	19	19	26
Av.	24.3	43.3	23.2	4.4	4.8	5.8	29.1	44.6	14.1	6.4		6.7	32.0	43.2	12.3	5.8		4.6	30.6	48	12.2	4.6		1.4	21.6	48.6	17.9	10.5	

REPORT OF COMMITTEE ON PRACTICAL CHEMISTRY TO NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.*

By John F. Woodhull, *Chairman,*
Teachers College, Columbia University, New York City.

There are about 1000 teachers of chemistry in the secondary schools of this state, but probably less than 50 of these are teachers of chemistry *exclusively.*

For purposes of investigation we have divided the high schools of the state into three classes:

Class 1.—Schools having teachers of *physical science, biology, earth science, etc.* (Departments which are represented by the various sections A. B. C. of this Association.)

Class 2.—Schools having teachers of *science.*

Class 3.—Schools having (just) teachers.

Class 1 includes 7% of the high schools of this state.

Class 2 includes 10% of the high schools of this state.

Class 3 includes 83% of the high schools of this state.

This association was formed in 1895 by certain members of Class 1 and has been sustained during these 17 years by members of that class. More than one-third of the members of Class 1 are in New York City. Those persons formed 15 years ago local associations such as The New York Physics Teachers' Club, The New York Chemistry Teachers' Club, The New York Biology Teachers' Club, etc. There are several other centers in the state where the same thing has happened. These study local problems and local industries for the purpose of making the instruction in the schools more practical. A good many of the schools which belong to Class 1 throughout the state have for one reason or another never been represented in this association. It therefore happens that this association with the all inclusive name of "The New York State Science Teachers' Association" represents only two or three per cent of the schools of the state.

Your Committee was instructed to find out how instruction in chemistry in the schools throughout the state might be made more practical—more vitally connected with life—more of an interpretation of the experiences of the pupils. It finds that during the last 17 years the tendency has been to make high

*Read before this association at Syracuse, December 27, 1912.

school chemistry a very complex system of doctrine with little attempt to give it local application.

Class 1 above referred to working under the immediate influence of the colleges has been largely responsible for the present prescription in high-school chemistry for New York State.

The members of Classes 2 and 3, although constituting more than nine-tenths of the schools of the state, have had practically no voice in the matter of this prescription. Perhaps a majority of the teachers of chemistry in the state are principals of schools. They do not as a rule attend the meetings of this association. Their own association has met annually in Syracuse at this season for 28 years.

The most obvious distinction which one might make between Class 1 on the one hand and Classes 2 and 3 on the other, is that a large number of the members of Class 1 are fresh from college and teach what they have been taught in the way they were taught it. They specialized in chemistry in college. They specialize in chemistry in high-school instruction. Their knowledge of other subjects is exiguous. Their experiences in life are too limited for them to meet high-school pupils upon their own ground. They are said to teach chemistry rather than pupils. In Classes 2 and 3 there appear to be a larger proportion of persons who understand their pupils and who know how to make chemistry mean something to them. Such have in many cases risen to principalships because of their wider knowledge of human nature. They are, in short, bigger men and women than specialists can be. They live in the smaller cities and towns and have fewer pupils to deal with. They have more direct contact with nature, with their pupils and with their pupils' homes. They are the persons who are making chemistry or any other subject which they may teach *vital*.

Our statistics show that members of Class 1 dwell on the average in cities of 112,000 inhabitants and teach in high schools of 1200 pupils, having 37 teachers to the school, each confining his attention to one subject. Members of Class 2 dwell on the average in cities of 15,000 inhabitants and teach in high schools of 165 pupils with 7 teachers to the school, each giving instruction in a group of allied subjects. Members of Class 3 dwell on the average in towns of 6,360 inhabitants and teach in schools of 70 pupils with 4 teachers to the school, each teaching pupils in groups of half a dozen with that personal contact which is the chief factor in all good instruction.

The Committee has visited many schools. In a typical case of the 3rd class we found a town of 5,000, a high school of 60 pupils and 3 teachers. The chemistry was taught by the principal. He is a leader in the life of that community. He has a house, a garden and a family. There is plenty of chemistry in his life. It gets into the school and enriches the lives of the pupils. We turn from this to a case in the 1st class, of whom there are some—a city of 100,000 inhabitants, a high school of 1,000 pupils and 35 teachers. An instructor who conceived the idea while in college that chemistry was his forte. He says he *majored* in chemistry. Under the guidance of his college adviser he took everything possible in chemistry and as little as possible in other subjects. The longer he stayed in college the fewer things he knew. He is now instructor in chemistry to 35 pupils in a school of 1,000. He has no garden to till. He lives in a hall bedroom and the students believe that contact with him is belittling.

The Committee thought that it could serve the teachers of the state best by acting as a clearing house. Hitherto a select few have prescribed for the many, and generally without sufficient knowledge of the conditions under which the many are teaching. The Committee, therefore, opened correspondence with individual teachers throughout the state urging each to write up his best lesson as a *"lesson help"* for other teachers. Several are now at work on attempts to make chemistry more practical. The Committee hopes to find a way to print as leaflets these "lesson helps" and distribute them to teachers throughout the state. The Committee hopes eventually to get the majority of the teachers of science in the state interested, either as active or as associate members, in the work of the New York State Science Teachers' Association. We hope in the course of time to find out who are the teachers with original ideas and to get such teachers to contribute their ideas through the channels of this association to help other teachers. A considerable pile of correspondence already received gives us much encouragement, and although none of this is in shape to present now we are glad to report progress.

In preparation for our work the Committee got together from the Commissioner's report and other sources a mass of statistics which are interesting even in their present undigested condition. They raise some questions as follows:

1. The statistics already presented in this report raise the

question whether after all *general science* now being so widely introduced throughout the country is not *more practical* than chemistry and physics.

2. The program of this meeting and the discussions now going on all over the country raise the question whether boys and girls must be segregated in order that the teaching of chemistry may be practical.

The U. S. Commissioner's Report gives only 6 high schools in New York state for boys alone and only 3 for girls alone, while there are 866 for both sexes. In the whole United States there are only 35 for boys alone and 27 for girls alone but 12,151 for co-education. Nine-tenths of the high schools are too small to make segregation possible and in the large ones the complexity of the program with all its electives makes it rarely possible to separate boys and girls in classes. Girls are present in all our classes and they predominate. They constitute 55% of all our high school pupils. Who thinks that the man who holds down a chair in some business office has more contact with problems of physical science than his wife with all her modern household appliances? The papers which have been presented at this meeting make it appear that girls have quite as much contact with practical physics and chemistry in life as boys have. Perhaps this talk about segregation is an *academic discussion*.

3. The question of men teachers vs. women teachers for chemistry or physics.

Women constitute 62% of all high school teachers. We desire to find out whether they are in the majority as chemistry teachers, and whether they are considered quite as satisfactory as men in such positions. The average salary for a high-school teacher in this state is now $1,100. It was $665 seventeen years ago when this association was born.

4. Should science be made practical in the same way that English has been of late years in the schools. Some of us can remember when English was the weakest subject in the schools. Here are some statistics to show that she is now the strongest. Your committee found that in one school library during a period of two months 993 readers appeared in pursuit of their work in English. 722 came for information in history but only 40 read because of their interest in science. There were in the library 3,915 volumes but only 71 of these pertained to physical science and two-thirds of these were the numerous text-books contributed by publishers.

5. Here is a group of statistics which raise the question whether teachers are practical.

In New York State 48% of high school pupils are in the 1st year class. We manage to eliminate more than one-third of these so that 26 per cent appear in the second year class. More than one-third of these disappear so that sixteen per cent are found in the third year class. More than one-third of these fail to reach their senior year and ten per cent are found in the fourth year class. A quarter of these are not allowed to graduate and eight per cent is the number of those who succeed. Half of these (four per cent) through "toil and trouble and tears" have prepared for college and the colleges think they are doing the Lord's service by rejecting half of these so that 2 per cent enter. There are plenty of people who raise the question whether these are superior or inferior to those who have dropped out by the way. These figures tabulated present the following appearance.

Of high school pupils in New York State there are 48% in 1st year class, 26% in 2nd year class, 16% in 3rd year class, 10% in 4th year class, 8% graduate, 4% prepared for college, 2% admitted. These statistics do not differ materially from those shown by the United States Commissioner's report for the high schools of the whole country.

If we were attempting to manage any other business with such a record as the above the question would be raised whether we were practical.

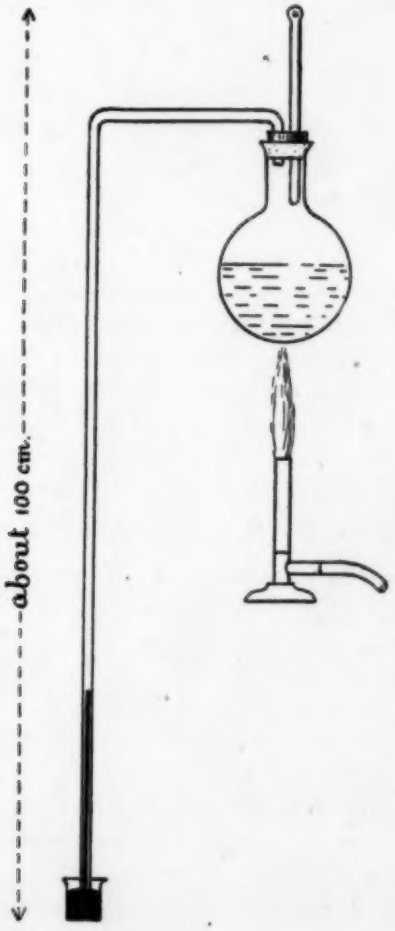
AN EXPERIMENT BOTH INTERESTING AND INSTRUCTIVE.

A very widely used laboratory manual in physics outlines an experiment designed to show the effects of a change in pressure upon the boiling point. The experiment is full of difficulties, and after trying it several times, I planned the following substitute, which gets the results, has a much wider range, and is far more instructive. It may possibly be an old experiment, but as I have never seen it in this form, I shall feel free to describe it. The following is a copy of the laboratory instructions furnished the pupil when this experiment is performed. It is perhaps better performed by the class as a whole, rather than individually. One who has never tried this experiment will be surprised at the splendid results that can be easily obtained in this.

Boiling Point of Water.

The object of this experiment is to show the effect that a change in pressure on a liquid has upon its boiling point, and to secure sufficient data to plot a number of points and draw a curve which graphically represents the relation between the change of pressure and the change in boiling point.

Tightly fit a rubber stopper carrying a thermometer and a doubly bent glass tube into a medium sized round bottom flask. The flask should be about half full of water (preferably distilled), and the thermometer should reach just down to the water. The part of the glass tubing that hangs down should be about a meter long, and there should be scratches on it at distances of



5 cm. and 10 cm. from the lower end. Put enough mercury into a small test tube to fill it to a depth of 10 cm. A small beaker or mercury cup should be in readiness for the second part.

When everything is in readiness, carefully apply heat and bring the water to the boiling point and keep it boiling until it is certain that all of the air has been expelled. Now record the barometer height and the temperature of the boiling water. Next place the lower end of the tube in the test tube of mercury to a depth of 5 cm. and as soon as the water boils, and the temperature becomes constant, record the temperature and the pressure. Now lower it to the 10 cm. mark and repeat the observations.

Now remove the test tube of mercury and pour the mercury into a small beaker of mercury. As soon as the water is again boiling vigorously seal the end of the tube with the beaker of mercury, and remove the flame. As the water continues to boil the mercury will rise in the tube because of the cooling and the condensation of the steam. The steam in the tube will also condense and form a layer of water on top of the mercury. At short intervals simultaneously take the following readings: Temperature, height of mercury, and the length of the water column in the tube. After it has cooled awhile it may be necessary to pour some cold water over the flask in order to get it to boil. Continue this as long as the water can be made to boil. In the first part the resultant pressure is evidently the barometric height plus the depth to which the tube was lowered into the mercury; while in the second part it is obtained by adding $\frac{1}{13.6}$ of the length of the water column to the height of the mercury and subtracting the sum from the barometric height. All the data should be recorded in the following form of record and should be filled out as the experiment progresses:

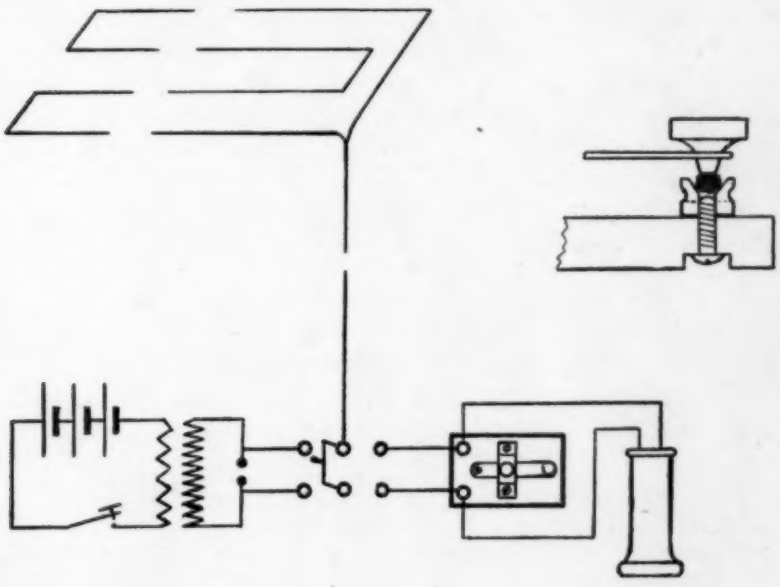
Temperature	Height of Mercury	Height of Water	Resultant Pressure

Plot the first and the last columns and select the units in such a way that the curve will cross most of the page. Ignore any point that seems entirely out of harmony with the rest. How can you tell from your graph whether the thermometer was graduated correctly or not? If the pressure were reduced to zero about what would be the boiling point?

AN INEXPENSIVE WIRELESS OUTFIT.

By H. Clyde Krenerick,
North Division High School, Milwaukee, Wis.

The following experiment, because of its simplicity and efficiency, was a surprise to me and a happy suggestion to many of the boys of my physics classes. The equipment does not include any apparatus but what is found in the average physics laboratory. One station is located in the lecture room, the other in the laboratory, a distance of one hundred feet, with four thick walls intervening, and satisfactory results are obtained.



The antennæ consist of a loop of annunciator wire strung on or near the ceiling in the "T" form. The two ends are brought together and connected to a double pole double throw switch so as to be used for both transmitting and receiving. The loop must of course be well insulated at all points. The other central connection of the switch is connected to the gas or water pipe which serves as the ground circuit. The transmitting apparatus consists of a small induction coil and spark gap. A quarter or half inch coil will be sufficient to transmit from one room to another. The spark gap may be obtained by placing in the secondary terminals two small metal rods terminating in lead balls.

The receiving apparatus consists of a simple contact key and an ordinary telephone receiver. The key acts as a detector of the silicon type. The key however must have platinum contacts and be of the form that can be permanently closed by means of a thumb screw. By adjusting this screw the desired pressure of contact is obtained.

The key can be made into a very sensitive detector by the simple modification shown in the sectional diagram. The lower contact is replaced by the nut of an English binding post. The upper opening of the nut has been enlarged by means of a drill, thus serving as a cup to hold the small piece of silicon which can be purchased for five or ten cents. The drilling can be omitted as the nut already has on one end the suggestion of a cup. The sensitiveness of this detector will compare well with that of the cheaper commercial forms and can be used for receiving messages transmitted from some distance. If the room is of sufficient size so that the antennæ contains two hundred or more feet of wire and if good ground connection is made, the above detector will receive, without tuning coil or other apparatus, the messages transmitted from commercial stations that happen to be located within a radius of two miles.

"A MINE OF INFORMATION."

Probably the most distinctive feature of the New International (G. & C. Merriam Co., Springfield, Mass.) is the amount of encyclopedic information that it contains. Wherever the reader turns he finds admirably condensed treatises, or tables, or illustrations. It is impossible to use the New International without being continually surprised by the range and completeness of the information furnished.

For example, most of us know the bare fact that malaria is spread by mosquitoes. If we look up *malaria*, or *mosquito*, we find, following an excellent definition, a cross reference to *Anopheles*, the genus of malarial mosquitoes. Under *Anopheles* is not only a discussion of the spreading of malaria by mosquitoes, but a description and an illustration by which you are enabled to tell at a glance whether the particular mosquito resting upon your sleeve is of the malarial variety.

To more important terms much more space is devoted (as *star*, two columns; *man*, two pages; *automobile*, three pages) so that their definitions are perfect mines of information. So completely does the New International cover all realms of knowledge that its possessor requires no other work of general reference. It has well been called, next to the Bible, the most valuable book in the English language.

Says President W. H. P. Faunce of Brown University, "The New International is a small encyclopedia covering the entire territory of the world's knowledge and the world's action."

The publishers offer specimen pages free.

THE TEACHING OF HIGH SCHOOL PHYSICS.

By Herbert Brownell,
Teachers College, The University of Nebraska.

It is my own thought that the *laboratory work* is or should be made the center and heart of all high school science teaching. There it is that the pupil makes his study of things and of phenomena, and exercises himself in intelligent observation, seeking to understand what is noted and to interpret his observations. The requirements of experimental work and its allied exercises constitute a series of difficulties to be mastered, of problems whose solution is sought. And it is to be noted in passing that in the selection and adaptation of such a laboratory course there is need to see to it that each succeeding exercise possesses an inherent interest and worth which invites to earnest endeavor. These requirements, too, demand in turn a painstaking effort in laying hold upon the facts presented, and an interpretation which reaches unfailingly the desired teaching ends.

In the laboratory the teacher and pupil come together as individuals, and the topics of discussion are those which at the time are of utmost importance to the pupil. His difficulties require assistance, and the teacher assumes in the pupil's mind a rightful and proper position—a guide, counselor, helper, and friend worth having. The laboratory period is a time for getting not only an understanding of terms and a skill in manipulation of apparatus, but as well the facts and phenomena whereby the pupil is prepared to profit to the largest degree from statements of book and teacher in class periods and in reference readings. It is the time of acquiring "apperceiving concepts," a time of lesson preparation of the most valuable sort, a "study period" under supervision.

It follows from any such consideration that the experimental work is to be simple in requirements made of the pupil, simple in apparatus needed, simple in skill in manipulation, and in degree of discernment and discussion demanded,—experimental work largely qualitative. During these laboratory periods, too, no better opportunity can ever offer for experimental work by the instructor for which preparation has been made in advance. Discussion of these teacher's experiments and the accompanying instruction changes individual laboratory work for the time being into a class room recitation or lecture period. This few minutes of interruption but adds zest and significance to the routine of the laboratory.

We ourselves have come to desire a double laboratory period daily, and not on Tuesdays and Thursdays only. All lesson preparation of whatever nature may thus be done under supervision, and at a time and in the room where apparatus and reference books as well as the help of the instructor are at hand. The study hours in the work are thus intimately associated with, and not arbitrarily separated from, recitation and laboratory work. No lesson preparation outside this double period daily is required. All solving of problems, all looking up answers to questions, all text and outline requirements, all quantitative experimental work, may thus be done under close and helpful supervision. There is made possible for the teacher a freedom in division of time devoted to each of the several phases of the work, with change from one to another when desired as governed by nature of the work in hand and by the varying attitude of pupils towards the work, whatever the causes therefor. It is to be noted here, too, that these added three hours per week in the physics room afford opportunity to the teacher to care in between times for laboratory equipment, to set up apparatus or to put it away, and that oftentimes by help of some of the pupils. There would then be no occasion in the smaller high schools for the science teacher to take an algebra class in these periods, or to have supervision of the assembly room, just because there was nothing else for him to do.

In thus emphasizing the possibilities of the work in the laboratory, there must be no minimizing of the value of class work. It is perhaps somewhat less important relatively than we are wont to make it, but having done well in this respect we are not to leave the antecedent and preparatory work of the laboratory undone.

It is during the review of the qualitative experiments the next day that opportunity is afforded the teacher for the best teaching effort. Into this review is to be brought from the teacher's fund of knowledge, and as required by outline and text, whatever of application and of information the teacher can give that is natural outgrowth of the facts from the pupil's own preparation and discernment in the laboratory exercises. The laboratory work has prepared the mind for the reception of this new matter and conditions are highly favorable for its organization and retention as new knowledge. All this requires that the qualitative experiments shall be worked no faster than the apperceiving concepts gained therefrom be used in succeeding class periods. There is

then possibility for use of quantitative experimental work not only for its own great purpose of accuracy in application of what has been taught, and for greater definiteness of grasp of this teaching, but as well and incidental to such use it makes easily possible the keeping abreast of both the class work and the related qualitative experimental work. It is to be noted, too, that in a prepared stock of quantitative experiments of approved intrinsic worth always ready at hand for use there is provided for the more rapid worker and brighter student full employment for time and talent of a nature fully worth doing for its own sake. For educational ends Physics never lacks in ample material for exercising the brightest pupils.

We close this presentation of Teaching Physics in High Schools by a brief summary of teaching procedure:

(1) A series of laboratory experiments and exercises preparatory to the teaching of the succeeding class period. (The laboratory papers of all pupils are to be handed in at the close of this work for review so far as shall be possible.)

(2) In connection with a class review and discussion next day of these laboratory papers, now again in the hands of the pupils, such teaching, illustration, and applications as the teacher can give, guided and assisted by a carefully prepared outline. Here it is that the subject should be developed to meet the several abilities of those under instruction, but as class work rather than individual instruction. Text assignments for the following day are to be made.

(3) A thorough quiz upon text matter and outline topics not previously covered in the teaching period, thus making complete the discussion of every topic in turn. As each larger division is completed, problems, quantitative experiments and exercises as applications of the teaching done. These are to be followed by an examination upon the division of the work covered.

ALASKAN COAL.

One of the markets available for Alaska coal, were the coal fields of the Territory developed, would be to supply coke to the smelters and foundries on Puget Sound and at Portland, San Francisco, Los Angeles and other cities on the Pacific coast. Most of the coke now consumed on the coast is imported from Germany or England or is brought from the Eastern states.

AGRICULTURE IN THE HIGH SCHOOL.

By Carl F. Knirk,
West Technical High School, Cleveland, Ohio.

The value of the teaching of agriculture is no longer questioned. It is fundamentally one of those subjects "in which the children learn to do those things which will have repeated application, and in the doing of which the children get control over them, to the end that they will increasingly utilize their physical surroundings." Accordingly more than two thousand schools of high school rank are today offering courses in agriculture, and the number is constantly increasing.

In assigning my topic your chairman requested that I limit my paper to two lines of thought. She suggested that I state briefly, first the purpose of a course in agriculture and secondly the means by which the purpose might be obtained. I shall, therefore, request that you turn your attention for a moment to a consideration of the first phase of this discussion.

Today, more than ever before, boys and girls everywhere are turning their attention to high school, hoping to learn to do those things in the doing of which they will acquire the ability to control themselves and master their surroundings to their own advantage and to the advantage of the great commonwealth of which they are a part. The boy who enters upon the duties of pursuing a course in agriculture has a right to expect that his training will enable him to gain a better living and make a better life than would otherwise be possible. To meet this requirement it becomes necessary to fit each course in agriculture to the community in which it is being given. Thus, the course given in a township high school must be quite different from that given in a high school in a large city. In the former the student should be prepared to meet the problems which are involved in the growing of field crops, while in the latter he should be prepared to meet those problems which have to do with truck-farming, market gardening and the growing of crops under cover. The former has to do with extensive farming and the latter deals with intensive farming.

If the city high school is to meet the obligation placed upon it and solve the problems involved in intensive farming, among other things its aim must be (1) to prepare boys to carry on the work of truck-farming and market-gardening, (2) to teach boys how to utilize the small space usually available for home

gardening, (3) to interest the general community in home-gardening and thus gain its coöperation, (4) to be of serivce to the community by giving assistance wherever it is possible to do so, (5) to keep the interest of the boy from the time he enters the high school until he has an opportunity to complete the course in agriculture, and finally to give the boy a systematic training which will prepare him to carry on further research either at home or in college. This places before the high school a large problem and upon it a tremendous obligation. And how are we, who are in the high school, going to solve this problem and meet this obligation? If you will pardon my being personal, I will tell you briefly how the work is being carried on at the West Technical High School.

A word as to equipment. The equipment consists of a greenhouse 26 x 118 feet, three acres of good land owned by the school, several vacant lots about the school, one young orchard of nearly 100 trees under the control of the school, all the necessary tools, a chemical laboratory and a laboratory in which agricultural experiments may be carried on.

The course now offered in this school covers a period of two years, one hour per day the first half year, two hours per day the second half, and four hours daily during the second year. In addition to this the boy must take one year in agricultural chemistry and he may take two years if he wishes. Before he can be admitted to agriculture, he must have completed two years work in the school which includes, among other things, one year in Industrial Geography and one year in Elementary Chemistry. So much for the general course; now let us see what some of the problems are which we encounter in trying to carry on the work along the lines indicated.

If boys who graduate from the high school are to be successful as market-gardeners and truck-farmers they must know something of the fundamentals involved in such work. And what are these fundamentals? The key to success in intensive farming lies in double-cropping which may be accomplished either by crop-rotation or crop-succession. But what are the principles which underlie double cropping? First of all we must know our crops intimately, the time required for each to mature, the soil conditions desirable, the moisture conditions favorable, the elements of plant food required, the life habits of the plants, and finally the insect pests and plant diseases to which the plant is subject. There are two reasons why it is necessary to know how

much time is required to mature each crop. It is frequently desirable to grow certain crops for a given market. Any crop marketed out of season, either earlier or later than the general season, brings an exceptionally high price. Other things being equal, a slight difference in the time of planting may mean a handsome profit to the grower. Secondly, a knowledge as to the time required in the maturing of each crop enables the grower to get the best result from a filler crop. The best results can only be obtained when crops of different harvesting seasons are combined. There must not be a long season between the time when the filler, or first-crop to mature, is removed and the time when the main crop needs all the space available, neither must the first crop be so late in maturing that it shades or is shaded by the other crop. From this it is evident that we must give our boys a rather intimate acquaintance with plants. They must know certain phases of botany, which some of you will call plant ecology.

I have said that knowledge regarding the soil conditions required by each crop is necessary. Different crops require different soils. Some crops yield well on coarse, well drained, warm soil, others are adapted to fine, water-retaining cold soil. Crops which yield well on the former type of soil may acquire diseases or even die on the latter type.

The facts demand that the boy be taught something regarding the physics and chemistry of soil.

The boy who knows something regarding the elements of plant food required by each crop will not combine crops of the same botanical family, neither will he grow a succession of crops of the same botanical family. For in either case the plants are likely to draw heavily on the same elements of plant food, and hence one or both crops would suffer from the combination or succession. Furthermore, the boy must know that the land planted has in it sufficient available plant food of every kind to assure the quickest and best possible growth of plants. For the quickest growing, heaviest yielding crops are usually of the finest quality and bring the highest price on the market. These conditions demand that the boy be taught considerable concerning plant nutrition and the chemistry of plants.

Lastly, this boy, who is to take his place as a market-gardener and truck-grower when he leaves the high school, must know something regarding the diseases and pests which are characteristic of certain groups of plants. This knowledge will keep him

from combining or growing in succession plants which belong to the same botanical family, and are, therefore, subject to the same insect pests and plant diseases.

I have already stated that the high school course should teach the boy how to utilize the small space usually available for home-gardening. The school can encourage home gardening by planting a small model garden in which all those things readily adapted to the most intensive farming are grown. A garden of this type can readily be duplicated and changed in size according to the space available.

Among the advantages to be gained through the home garden are the following: (1) The boy has something to interest him at home and keep him off the streets; (2) It will lead to the cleaning of many back yards which would otherwise be disease and fly-breeding centers, and (3) It will help in a small measure to solve the problem of the high cost of living.

For the above reasons, the general community should also be interested in home gardening.

One of the important reasons for offering a course in agriculture in the high school is that the general community needs the assistance which the pupils and teachers can give. This assistance can be given in various ways. The classes can assist gardeners and farmers in the community (1) by testing and grading seed, (2) by making an analysis of soils, (3) by making an analysis of fertilizers, and (4) by developing experimental plots outside as well as within the school gardens. Work of this nature has a double value. It assists the community in solving its problems and it gives the boys a splendid training. For this reason our boys have arranged to care for a very interesting orchard of nearly 100 trees. The trees in this orchard are ten years old. The man who planted and cared for them until July, 1912, believed that nature should take its course and that man should not interpose. One can hardly imagine the condition of this orchard today. The trees have a superabundance of wood, San Jose scale is present, the coddling moth has established headquarters in every tree, some of the fruit is of undesirable varieties and some trees have been injured and are rapidly decaying as a result. The present owner of the orchard believes that the orchard needs care. Accordingly, this orchard is to become an experimental plot for our boys. Pruning, grafting, spraying, etc., is to be done by our boys and the owner will pay for the cost of the materials. It is too early to predict the results, but my firm

conviction is that the owner will feel well repaid for coöperating with the school and that the boys will get the very finest training possible. Furthermore, I am certain that it will not be hard to keep the boys interested in their school work when we have live problems like this to handle.

This leads me to the next point. How are we going to keep the boy interested in agriculture during the first two years in the high school when he is not enrolled in agriculture? Through the work of the Home Gardening Association, the grade schools, and various other organizations. Many grade school boys are interested in agriculture. When they enter the high school all connection with these organizations is usually broken and unless their interest is maintained through the efforts of the high school they are likely to give their efforts to something else and lose all interest in agriculture. We hope to keep these boys interested by organizing a high school Gardening Association. All boys now in agriculture and all boys who expect to enter agriculture when they become juniors in the school are eligible to this organization. The ground for such gardens is found in vacant lots which can be secured at a nominal cost. The implements and seed are supplied by the school. All of the work is under the supervision of the school and when a boy fails to do his work according to instructions he forfeits his right to a plot. After the expenses are paid the profits are equally divided between the boy and the school. This plan, we believe, will work well, because we find it a success in all our other technical departments and we believe that it will keep the boy interested in agriculture.

In conclusion, it seems to me that the demands placed upon the high school teacher of agriculture are as follows:

(1) Study the demands of the community.

(2) Prepare the boys to meet these demands.

(3) See to it that we give and get from the community the most assistance consistent with good work.

(4) Keep the boys interested by giving them something to do and, finally give the instruction in a systematic manner so that the boy will be prepared to carry on further research work either at home or in college.

Thus we will hasten the day when all schools will teach this great subject "in which the children learn to do those things which will have repeated application, and in the doing of which the children get control over them, to the end that they will increasingly utilize their physical surroundings."

AN APPROXIMATE SOLUTION OF THE PROBLEM OF THE DUPLICATION OF THE CUBE.[1]

By A. A. Dmitrovsky,
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The classical problem, to construct a cube, the volume of which shall be twice the volume of a given cube as it is known, cannot be solved by elementary geometry, *i. e.*, by means of a ruler and compasses only. This is due to the fact that if we denote the edge of a cube by a and the edge of another cube (the volume of which equals twice the volume of the given cube) by x, then in order to find x we shall have to solve the cubic equation

$$\left(\frac{x}{a}\right)^3 - 2 = 0.$$

This equation is irreducible, *i. e.*, its left side cannot be resolved into factors with rational coefficients, for otherwise one of the factors would be of the first power and of the form

$$\frac{x}{a} - L,$$

and then one of the roots of the given equation would be equal to a rational number L, while

$$\frac{x}{a} = \sqrt[3]{2}$$

and $\sqrt[3]{2}$ is an irrational number.

There are many methods of solving this problem by means of conic sections and of higher plane curves, and there are instruments for the mechanical solution of this problem. A few approximate solutions by means of a ruler and compasses have been proposed. Such are the solutions of Vargui, Buonafalce, Boccali, and others. (See Enriques *"Questioni riguardanti la geometria elementare,"* Bologna, 1900, pp. 437-445.) These solutions differ as to the method of the construction and to the degree of accuracy attained. But they have in common the defect of requiring a long series of computations, for the most part the extraction of square roots, to many decimal places, in order to obtain a fair degree of accuracy. The simple construction given below solves the problem with a considerable degree of accuracy without any computations.

It is known that $\sqrt[3]{2} = 1.2599209$. Therefore, if we suppose

[1]Translated for this Journal from the Russian by A. Babbitt, student of the Pennsylvania State College.

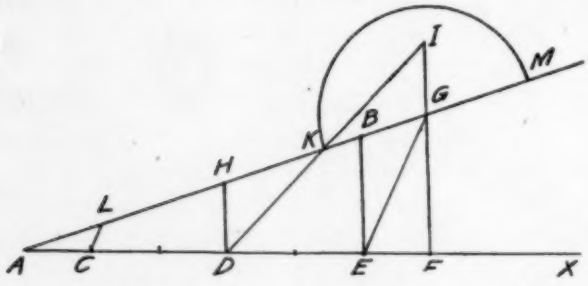
$\sqrt[3]{2}=1.26$, the error will be less than 0.00008, or less than $1/12500$. This means that if a is the edge of a given cube then $x=1.26a$ is the edge of a double cube with an error less than $a/12500$.

To construct x in a simple way, we have:

$$x = 1.2a+0.06a, \text{ or}$$

supposing $1.2\ a=b$,

$$x = b+\tfrac{1}{20}b = b+\tfrac{1}{4}b-\tfrac{1}{5}b\,.$$



Let AB=a, be the edge of the given cube. Produce AB. Through A draw a straight line AX and lay off on it six equal segments. Join E, the end of the fifth segment and B, and pass through D, the end of the third segment, and through F, the end of the sixth segment, straight lines DH and FG parallel to EB. Upon FG produced lay off GI=OH. Join D and I, and let DI intersect AB in the point K. Lay off GM=KG and join E and G. Pass through C, the end of the first segment the straight line CL parallel to EG. Then LM=x.

It is evident, that

$$\text{AG} = 1\tfrac{1}{5}a = b,$$
$$\text{AH} = \text{HG} = \tfrac{1}{2}b;$$

and

$$\text{KG} = \text{GM} = \tfrac{1}{4}b.$$

From the equality of the triangles HDK and KIG,

$$\text{AM} = b+\tfrac{1}{4}b,$$
$$\text{AL} = \tfrac{1}{5}b, \text{ and}$$
$$\text{LM} = b+\tfrac{1}{4}b-\tfrac{1}{5}b = x$$

Hence, LM is the edge of a double cube with $1/12500$ as the degree of accuracy. If the edge of the given cube is 10 m., the error is less than 1 mm.

ERRORS IN MATHEMATICS.

By G. A. Miller,
University of Illinois.

Although mathematics is probably more nearly free from important incorrect statements than any other extensive subject, yet there exists in the literature of mathematics a large number of serious errors. These errors are not restricted to the literature of any one period but they are doubtless relatively more numerous in the early literature than in recent publications. As is well known, the ancient Egyptian work entitled, "Directions to Arrive at an Understanding of All Dark Things," which was written by Ahmes as early as 1700 B. C., contains a very large number of errors. For instance, in this work the area of an isosceles triangle is made equal to the product of one of the two equal sides and one-half the base.

There are a few problems which may be regarded as perennial sources of errors. Among these are the problem of finding the ratio between the diameter and the circumference of a circle, and the parallel axiom of Euclid. In recent years Fermat's larger theorem has taken the foremost place among these perennial sources of errors. This general interest is due mainly to a prize of about twenty-five thousand dollars for the first successful proof of this theorem, which affirms that the equation

$$x^n+y^n=z^n,\ n>2,$$

cannot hold when x, y, and z are rational numbers and n is a positive integer. During the past few years more than a hundred incorrect proofs of this theorem have been published yearly, and the stream of this erroneous literature does not seem to have yet lost any of its vigor.

While the greater part of this literature is produced by people of little mathematical training and of less mathematical insight, a portion of it is due to men of good ability. In support of the latter part of this statement we need only refer to the memoir of 82 pages by Ferdinand Lindemann, Professor of Mathematics in the University of Munich, which he published in 1909 under the title "Ueber den sogenannten letzten Fermat'schen Satz." In 1910, F. Hansdorff reviewed this memoir, and called attention to its main errors, in a German mathematical journal called *Jahresbericht der DeutschenMathematiker-Vereinigung*, pages 35 and 36. The given memoir was also reviewed by Albert Fleck

in the journal called *Archiv der Mathematik und Physik*, which has devoted considerable attention to the errors occurring in a large number of the supposed proofs of Fermat's theorem. These errors should be studied especially by those who are interested in striving for the great prize mentioned above.

The Göttingen Academy of Science, which is in charge of this prize, has simplified its own work at the great expense of the rest of the mathematical world, by announcing that it will consider only published work in reference to this prize. It is too early to predict the extent of the erroneous literature which the Göttingen Academy has indirectly called into existence through this resolution. Hundreds of people, whose worthless manuscripts would have required only a few minutes time for some member of this committee, have already, by their publications, increased the labors of the student, the bibliographer, and the librarian for all future times. It is, of course, true that some people would have mailed manuscripts which fortunately they did not publish, but it is questionable whether this includes all of the worst material. As the prize may be given for work accomplished before September 13, 2007, it is hard to foresee the volume of this erroneous literature; but the indications are that it will be enormous, unless some one discovers the solution long before the expiration of prescribed period.

Many students meet mathematical errors for the first time in answers to the problems in their text-books. These errors often have a very beneficial effect on the student as they direct attention to the fact that authors of text-books are not infallible, and hence to the need of proving the various statements before accepting them. If such errors aid the student to regard text-books as means to arrive at important laws and at fundamental principles, instead of as depositories where one should seek these laws and principles, they will have a most salutary effect. It is true that this effect should be produced by nobler means, but too little conscious effort is made in this direction, and authors as well as teachers frequently make the most helpful impressions on students by incidents which they were eager to avoid.

The salutary effect of errors is not confined to those which the student meets in his text-books, but the discovery of errors in the writings of leading mathematicians has often served as a much needed encouragement to the young investigator. Fundamental principles of far reaching applications are, however, still more helpful to the young seekers after truth. While due credit

should be given to certain good influences arising from errors it must not be forgotten that very baneful influences may issue from the same source, and that errors should, in general, be regarded as weeds in the intellectual field.

It would be difficult to establish a relation between the value of a work and the number of errors which it contains. Some of the most influential works that have ever appeared involved a large number of errors. As an instance of this fact we need only refer to the classic work of Gauss which appeared in 1801 under the title *Disquisitiones Arithmeticae*. On the other hand, some of the most useless works are comparatively free from error. The character of the errors is much more important than their number in determining the usefulness of a book. As a rule, text-books written by men of little mechanical ability are of little value even if they are comparatively free from errors, while those written by real mathematicians are nearly always more useful even if they should contain a larger number of errors.

The awakening of thoughts is a much more important function of the text-book than the furnishing of thoughts, and an author who has no original thoughts is not likely to put things into the best form for awakening thoughts unless he copies almost verbatim. Even in this case he is apt to copy the wrong things. There is a great disadvantage in the use of text-books which the student and the teacher cannot criticise freely beyond the correction of evident errors. Few things are more harmful to mathematical growth than the assumption that the text-book is perfect both as regards the choice of material and as regards method of presentation. Much could be said in favor of the proposition that a text-book should never be used in an institution where conditions tend to curb its open discussion, even if it should be otherwise most suitable.

Three important classes of mathematical errors are as follows: (1) Those which result from mistakes in calculation according to correct general methods, (2) Those which result from a misunderstanding of some general principle or from ignorance as regards laws related to the question under consideration, (3) Those due to ignorance as regards historic facts.

If one would undertake to form lists of each of these classes of errors it would not take long to secure a large collection. In fact, under certain restrictions such a list has been in the course of construction during the last nine years. In 1904, E.

Maillet started a brief list of errors of renowned deceased mathematicians, as a partial answer to question number 2855, in a French mathematical journal called *L'Intermédiaire des mathématiceans*. A number of different mathematicians have contributed to this list from time to time so that it has become quite extensive.

Many of the errors noted in this list relate to somewhat advanced subjects but some of them relate to fundamental matters in elementary mathematics. For instance, in 1907 the noted French mathematician J. Hadamard called attention to several errors made by Cauchy in reference to proofs of theorems in elementary solid geometry. In particular, he noted that there are lacuna in Cauchy's proof of the theorem that two convex polyhedrons which have the faces equal each to each and arranged in the same order are equal or symmetric, and that these lacuna had not been removed up to that time.

A collection of errors which promises to become very extensive and very valuable for the specialist is given in the *Tribune publique* of the great French mathematical encyclopedia, which is in course of publication. Both the German and the French editions of this great encyclopedia have invited the public to assist in correcting errors in the published parts of this work. The corrections of the German edition appeared, until 1907, in the journal called *Archiv der Mathematik und Physik*, which we mentioned above in connection with Fermat's problem. Since 1907 these corrections have appeared in the journal of the German Mathematical Society. The corrections to the French edition appear as a separate part in connection with the new numbers of this encyclopedia.

The cordial public invitation by the directors of the two editions of the great mathematical encyclopedia, to assist in the warfare against mathematical errors, presents one of the most interesting developments in the search for the truth. It offers also one of the most convincing arguments in favor of the great difficulty of avoiding errors, and it tends to show that doing nothing to advance our knowledge of mathematics is practically the only sure way to avoid making any mathematical errors. The substance of the last part of the preceding remark seems to apply also to the other sciences.

The most powerful single factor tending to check the rapid growth of mathematical errors is doubtless the German mathe-

matical review called *Jahrbuch ueber die Fortschritte der Mathematik*. As its name implies, this publication is issued annually and it reviews the articles which appear in the leading mathematical journals of the world, as well as the principal books. These reviews are written by about sixty different men who are especially qualified along the lines of the articles and books which they undertake to review, and hence their criticisms are generally received with confidence. Even this work is not free from errors, and the reviewers differ widely as regards their attitude towards short-comings, but the fact that articles and books are exposed to a critical review has doubtless exercised a most salutary influence, and has tended to reduce greatly the number of errors in the literature which is offered for publication.

Students who do not have easy access to large libraries are often deceived as regards the reliability of works of reference by the boastful advertisements employed by publishers. Attention has recently been called, in the journal called *Science*, to a number of mathematical errors in the latest edition of the Encyclopedia Britannica.* Among the dictionaries of the English language, the Century Dictionary and Cyclopedia is deservedly popular. The great claims for scholarship in some of the advertisements of the revised and enlarged edition of this work which appeared in 1911, led the present writer to consult, with some care, the material appearing under one word, namely, the word "group."

It would perhaps be too much to expect that a popular dictionary would give a scholarly treatment of the technical mathematical use of a word having such a wide range of applications as the word group, but it seems that even those who are willing to make all reasonable allowances could not feel satisfied with the material appearing under this word. The mixture of errors and useless or obsolete matter, and the omission of many of the most important modern concepts associated with the term, did certainly not seem to harmonize with the great claims in the advertisements.

In support of this stricture we may cite that under "isomorphous groups" it is stated that these groups "can be separated each into the same number of subgroups so that a substitution of a subgroup in the one can be so coördinated to one of the other that products shall correspond to products." As a matter of fact, it is not true that isomorphous groups, as here used, can

*Science Dec. 1, 1911, and Jan. 5, 1912.

be separated into the same number of subgroups. The separation into subgroups has nothing to do with this general isomorphism. On the contrary, the concept of quotient group is used in isomorphisms but this is not mentioned. Instead of such fundamental expressions as quotient-group, group of isomorphisms and commutator subgroups, we find such useless and antiquated terms as "potential group" and "anti-potential group." Even the definition of the mathematical concept involved in group is not in accord with that found in the good modern treatises on this subject.

The term "alternating group" is almost universally used for the group formed by all the positive substitutions on n letters. On the contrary, we find the statement that the alternating group is "a group of alternating numbers"; a definition which would probably be new even to authors of modern works on group theory. The quaternion group is defined as "a set of quaternions whose products and powers are members of the set." Such a definition of quaternion group might suggest itself to one who knew something about the definition of a group and knew that there were such things as quaternions, but if one knew that the term quaternion group had been adopted as the name of the special abstract group which is simply isomorphic with the group of multiplication formed by the eight quaternion units, the given definition would not appear to be instructive.

In the group theory literature it is customary to speak of commutative groups as groups in which the operators or elements are commutative. On the contrary, the Century Dictionary speaks of two groups as commutative when they are "such that the product of two substitutions belonging to the one and the other is independent of the order of the factors." According to this, either of these two groups, or both of them, might be non-abelian, and yet the two groups could be called commutative. Under the definition of antipotential group it is stated that "each of the cyclic substitutions α, β, γ, etc., is a substitution of the antipotential group." In fact, these substitutions do not necessarily consist of a single cycle and hence they are not always cyclic unless we call every substitution cyclic.

In turning to the term isomorphism we found the statement that holoedral isomorphism in mathematics is the "identity of the form of two groups." As a matter of fact, two groups which have the same form need not be holoedrically isomorphic, regardless of the fact that the etymology of the term suggests this. It is, however, scarcely necessary to continue these citations. The

Century Dictionary is an excellent work as a whole, notwithstanding a number of errors. It would, of course, be very desirable if the publishers of such great works of reference could see their way clear to engage the services of more real scholars. At any rate, the fact that our American works of reference are not, as rule, free from grave mathematical errors should be generally known, as it would naturally tend towards improvements.

If we turn our attention to historical errors in the mathematical literature we find a somewhat discouraging situation. One of the most popular works on mathematical history in the English language is Ball's "Short Account of the History of Mathematics." This was translated into Italian and also into French notwithstanding its numerous errors. Many of these errors are pointed out in a review by G. Eneström published in volume 10 of the *Bibliotheca Mathematica*, pages 85 to 88. The fact that this work has become so popular in spite of its numerous errors seems largely due to the wide spread and dense ignorance as regards the history of mathematics even among mathematicians.

It appears, however, that there is a rapid change in progress along this line. The very rapid advance in historical knowledge during the last few decades is evidence of the fact that there is a growing general interest in the history of mathematics, and with this growth there will naturally come better facilities to acquire reliable information along this line. At present, the student cannot be too careful to consult most recent and reliable sources of information along historic lines, and to weigh very carefully the arguments which are advanced in support of general historic theories. It is to be hoped that the rapid exposure of old errors will tend to cultivate a spirit of caution and hence to check the rapid growth of new ones. Possibly the interest in the critical study of foundations and methods will be rapidly extended to the domain of history. The large German and French mathematical encyclopedias seem to point this way.

In conclusion, we desire to direct attention to errors due to inaccuracy in the statement of correct ideas. As an instance, we may cite the common statement that the whole is equal to the sum of all its parts. On the other hand, most students would probably readily agree that each of the numbers 1, 2, 3, 4, 6, etc., is a part of 12, although their sum evidently exceeds 12. Accurate statements doubtless tend towards accurate thinking, and a keen dislike for all kinds of errors is one of the important ends of mathematical instruction.

SOME PROPERTIES OF RATIONAL PLANE TRIANGLES WHOSE SIDES ARE WHOLE NUMBERS.

By Artemas Martin, LL. D.,
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A *rational* triangle is a triangle whose sides and area are expressible by rational numbers. If the sides are whole numbers having no common divisor, the triangle may be called a *prime* triangle.

A *plane* triangle is a triangle whose sides are straight lines, and whose surface is a plane. Only plane triangles are considered in this paper.

A *right-angled* triangle is a triangle having two of its sides perpendicular to each other; these two sides are called the *legs* of the triangle, and the other side is called the *hypotenuse*. Such triangles are also called *right* triangles.

A triangle having all three of its angles less than a right angle is called an *acute* triangle; a triangle having one angle greater than a right angle is called an *obtuse* triangle. These triangles (acute and obtuse) are also called *scalene* triangles.

I. Right Triangles.

It has been known for centuries that the expressions $2pq$, p^2-q^2, p^2+q^2 represent the sides of a right triangle for all possible values of p and q, where $2pq$, p^2-q^2 are the legs and p^2+q^2 the hypotenuse. In order that the triangle may be prime, p and q must be prime to each other, one odd and the other even.

1.—The sum of the hypotenuse and the leg $2pq$ is always a square number.

Proof.—$(p^2+q^2)+2pq=p^2+2pq+q^2=(p+q)^2$.

2.—The difference between the hypotenuse and the leg $2pq$ is always a square number.

Proof.—$(p^2+q^2)-2pq=p^2-2pq+q^2=(p-q)^2$.

3.—The sum of the hypotenuse and the leg p^2-q^2 is always double a square.

Proof.—$(p^2+q^2)+(p^2-q^2)=2p^2$.

4.—The difference between the hypotenuse and the leg p^2-q^2 is always double a square.

Proof.—$(p^2+q^2)-(p^2-q^2)=2q^2$.

5.—*One* of the legs of a prime right triangle is divisible by 3.

Proof.—This will evidently be the case when either p or q is divisible by 3; but when neither is divisible by 3 we have

$p=3\,m+1$ or $3\,m+2$, $q=3\,n+1$ or $3\,n+2$,

and for any one of the combinations

$p=3\,m+1$, $q=3\,n+1$ or $3\,n+2$;

$p=3\,m+2$, $q=3\,n+1$ or $3\,n+2$,

p^2-q^2 is divisible by 3.

6.—*One* of the legs of a prime right triangle is divisible by 4.

Proof.—Since either p or q is even, it follows that the side $2pq$ is always divisible by 4.

7.—*One* of the sides of a prime right triangle is divisible by 5.

Proof.—This will evidently be the case when either p or q is divisible by 5, for then $2pq$ is divisible by 5. When neither p nor q is so divisible by 5, then either p^2-q^2 or p^2+q^2 must be divisible by 5, and we have

$p=5m+1$ or $5m+2$ or $5m+3$ or $5m+4$,

$q=5n+1$ or $5n+2$ or $5n+3$ or $5n+4$.

When $p=5m+1$, for $q=5n+1$ and $q=5n+4$, p^2-q^2 is divisible by 5; and for $q=5n+2$ and $q=5n+3$, p^2+q^2 is divisible by 5.

When $p=5m+2$, for $q=5n+2$ and $q=5n+3$, p^2-q^2 is divisible by 5; and for $q=5n+1$ and $q=5n+4$, p^2+q^2 is divisible by 5.

When $p=5m+3$, for $q=5n+2$ and $q=5n+3$, p^2-q^2 is divisible by 5; and for $q=5n+1$ and $q=5n+4$, p^2+q^2 is divisible by 5.

When $p=5m+4$, for $q=5n+1$ and $q=5n+4$, p^2-q^2 is divisible by 5; and for $q=5n+2$ and $q=5n+3$, p^2+q^2 is divisible by 5.

Hence some *one* of the sides is always divisible by 5.

8.—The area of a prime right triangle is divisible by 6.

Proof.—The area is $pq(p^2-q^2)$. Either p or q is divisible by 2, and we have already shown that p^2-q^2 is always divisible by 3 when neither p nor q is divisible by 3; hence $pq(p^2-q^2)$ is always divisible by $2\times3=6$.

9.—The continued product of the three sides of a prime right triangle is divisible by 60.

Proof.—The continued product is

$$2pq\times(p^2-q^2)\times(p^2+q^2).$$

It has been shown that $2pq$ is always divisible by 4; that, when neither p nor q is divisible by 3, p^2-q^2 is divisible by 3; and that, when neither p nor q is divisible by 5, either p^2-q^2 or p^2+q^2 is divisible by 5; therefore

$$2pq\times(p^2-q^2)\times(p^2+q^2)$$

is always divisible by $4\times3\times5=60$.

10.—The hypotenuse of a prime right triangle is an *odd* number.

Proof.—Since p^2+q^2 is *odd* when p and q are prime to each other and one odd and the other even, therefore, the hypotenuse of a prime right triangle is always an odd number.

11.—*One* of the legs of a prime right triangle is an odd number.

Proof.—Since p^2+q^2 is *odd* when p and q are prime to each other and one odd and the other even, therefore, one of the legs of a right triangle is always an odd number.

12.—Every *odd* number greater than 1 is the shorter leg of a prime right triangle.

Proof.—Let x, y be the legs and z the hypotenuse; then

$x^2+y^2=z^2$ or $z^2-x^2=y^2$.

Assume $y=2n+1$, then

$z^2-x^2=(z+x)(z-x)=y^2=(2n+1)^2=4n^2+4n+1$.

Take $z-x=1$, then $z+x=4n^2+4n+1$; from which we get

$$z=2n(n+1)+1,\ x=2n(n+1),$$

where n may be any positive whole number. Hence $y=2n+1$ may be any odd number greater than 1, and y is always less than x.

Taking $n=1$, the sides of the triangle are 3, 4, 5;

Taking $n=2$, the sides of the triangle are 5, 12, 13;

Taking $n=3$, the sides of the triangle are 7, 24, 25;

Taking $n=4$, the sides of the triangle are 9, 40, 41;

and so on, indefinitely.

The sum of the hypotenuse and longer leg is equal to the square of the other leg; for,

$[2n(n+1)+1]+[2n(n+1)]=4n^2+4n+1=(2n+1)^2=y^2$.

13.—The double of any even number greater than 2 is the shorter leg of a prime right triangle.

Proof.—Representing the sides by x, y, z, as above, if we take $y=2n$,

$$z^2-x^2=4n^2;$$

and if we take $z-x=2$, we have $z+x=2n^2$; whence $z=n^2+1$, $x=n^2-1$, where n may be any *even* number greater than 2.

If $n=4$, the sides are 8, 15, 17;

If $n=6$, the sides are 12, 35, 37;

If $n=8$, the sides are 16, 63, 65;

If $n=10$, the sides are 20, 99, 101;

and so on, indefinitely.

Twice the sum of the hypotenuse and longer leg is equal to the square of the other leg; for,

$2[(n^2+1)+(n^2-1)]=4n^2=(2n)^2=y^2$.

II. Scalene Triangles.

14.—Two of the sides of a rational prime scalene triangle must be *odd*.

Proof.—Let $2m+1$, $2n+1$, $2p$ denote the sides of a prime scalene triangle; then their sum is

$$2m+2n+2p+2,$$

an *even* number, and the area of the triangle is

$$\sqrt{[(m+n+p+1)(m+n-p+1)(m+p-n)(n+p-m)]},$$

which must be a whole number.

The sides can not be all even, for in that case the triangle would not be prime.

Suppose the sides are all odd and are $2m+1$, $2n+1$, $2p+1$; then their sum is

$$2m+2n+2p+3,$$

which is not an even number, and therefore the area can not be a whole number when the sides are all odd.

Suppose the sides are two even and one odd, and are $2m$, $2n$, $2p+1$; then their sum is $2m+2n+2p+1$, which is not an even number, and therefore the area can not be a whole number when the sides are two even and one odd.

15.—The shortest side of a prime rational triangle can not be less than 3.

Proof.—(α) The difference of two sides of a triangle must be less than the third side. The difference between the sides when integral can not be less than 1; hence the least side can not be 1.

(β) If the shortest side be 2, the difference of the other two sides can not be 2, and must therefore be 1; but, since two of the sides of a prime triangle must be odd, it is obvious that if the difference of two of the sides be 1, one of them must be even, and it follows that a prime rational triangle can not have a side $=2$.

(γ) Since the least side of a prime rational triangle can not be 1, nor 2, therefore it can not be less than 3.

16.—The difference between the sum of the two shorter sides of a rational prime triangle and the longest side can not be unity.

Proof.—Let $2m+1$, $2n+1$ and $2p$ denote the sides; then, taking p to be the longest side,

$$(2m+1)+(2n+1)-2p=2m+2n+2-2p,$$

which is divisible by 2 and can not, therefore be 1.

Supposing $2m+1$ to be the longest side we have

$(2n+1)+2p-(2m+1)=2m+2p-2m,$
which is also divisible by 2 and can not be 1.

If $2n+1$ be supposed the longest side, the result will be divisible by 2.

17.—The area of any prime rational triangle is divisible by 6.

Proof.—Any prime triangle can be divided into two right triangles by drawing a perpendicular from the greatest angle to the side opposite. The area of each of which has been shown to be divisible by 6, and therefore the area of the triangle which is their sum is also divisible by 6.

18.—Every whole number greater than 2 is the shortest side of an infinite number of prime triangles.

Proof.—(δ) When the least side is odd, let it be $2a+1$, and the other two sides x and $x+2b+1$, where $a>b$; then the area of the triangle is

$$\sqrt{[(a-b)(a+b+1)(x-a+b)(x+a+b+1)]},$$

which must be a rational whole number, and we must have

$$(a-b)(a+b+1)(x-a+b)(x+a+b+1)=\square,$$

$$=\frac{q^2}{p^2}(a-b)^2(a+b+1)^2(x-a+b)^2, \text{ say};$$

whence we get

$$x+a+b+1=\frac{q^2}{p^2}(a-b)(a+b+1)(x-a+b),$$

and

$$x=\frac{(a+b+1)[p^2+(a-b)^2q^2]}{(a-b)(a+b+1)q^2-p^2}$$

The above value of x will be integral when

$$(a-b)(a+b+1)q^2-p^2=\pm 1 \quad \ldots\ldots\ldots\ldots\ldots (1)$$

The equation

$$p^2-(a-b)(a+b+1)q^2=+1 \quad \ldots\ldots\ldots\ldots\ldots (2)$$

is always possible for integral values of p and q when $(a-b)(a+b+1)$ is not a square number.

The sides of the triangle corresponding to (2) are, if we substitute $(a-b)(a+b+1)q^2+1$ for p^2,

$$2a+1,\ (a+b+1)[(2a+1)(a-b)q^2+1]-(2b+1), \text{ and}$$
$$(a+b+1)[(2a+1)(a-b)q^2+1],$$

changing the signs of the second and third sides to make them

positive, where a may be any whole number and b any whole number less than a.

The indeterminate equation (2) has an infinite number of values for each value of a, and for each value of b, hence every *odd* number greater than 1 is the shortest side of an infinite number of prime triangles.

(ϵ) When the least side is *even*, let it be $2a$, and the other two sides x and $x+2b$, $a>b$; then the area is

$$\sqrt{[(a-b)(a+b)(x-a+b)(x+a+b)]},$$

and we must have

$$(a-b)(a+b)(x-a+b)(x+a+b)=\square,$$

$$=\frac{p^2}{q^2}(a-b)^2(a+b)^2(x-a+b)^2, \text{ suppose;}$$

then $$x+a+b=\frac{p^2}{q^2}(a^2-b^2)(x-a+b);$$

whence $$x=\frac{(a+b)[p^2+(a^2-b^2)q^2]}{(a^2-b^2)q^2-p^2}$$

which will be an integer when

$$(a^2-b^2)q^2-p^2=\pm 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

This condition is always possible for the lower sign when a^2-b^2 is not a square, and for this case the sides of the triangle are

$$2a,\ 2a(a^2-b^2)q^2+(a-b),\ 2a\ (a^2-b^2)q^2+(a+b).$$

Take $b=1$, then we have

$$p^2-(a^2-1)q^2=+1,$$

and the sides of the corresponding triangle are

$$2a,\ 2a(a^2-1)q^2+(a-1),\ 2a(a^2-1)q^2+(a+1)\ldots\ldots\ldots(A).$$

Take $b=2$, then we have

$$p^2-(a^2-4)q^2=+1,$$

and the sides of the triangle are

$$2a,\ 2a(a^2-4)q^2+(a-2),\ 2a(a^2-4)q^2+(a+2)\ldots\ldots\ldots(B)$$

Since a^2-1 and a^2-4 can never be squares for any integral values of a, it follows that the equation

$$p^2-(a^2-1)q^2=+1$$

is possible for all values of a greater than unity; and that the equation

$$p^2-(a^2-4)q^2=+1$$

is possible for all values of a greater than 2.

When a is odd the sides given by (A) are divisible by 2, and when a is even the sides given by (B) are divisible by 2; hence when a is odd (B) will give prime triangles, and when a is even (A) will give prime triangles.

As these two sets of formulas, (A) and (B), include all integral values of a greater than unity, they will give prime triangles with the shortest side equal to any even number greater than 2. Hence any even number greater than 2 is the shortest side of an infinite number of prime rational triangles.

It has been shown in (δ) that every *odd* number greater than 1 is the shortest side of an infinite number of prime rational triangles; therefore, it follows from what has been done that *every* integral number greater than 2 is the shortest side of an infinite series of prime rational triangles.

COAL LAND.

It is a widespread popular impression that if coal is found outcropping on a tract, the land is coal land, and that if no coal is to be found outcropping the land is non-coal land. If this were true probably more than one-half of the coal produced in the country (in some states more than 95 per cent) would be coming from mines not on coal land. As an illustration, 196 mines in Indiana in 1908 produced 11,997,304 tons of coal. Of these 196 mines, 15 were working the coal from the outcrop and produced 400,733 tons, or a little over 3 per cent of the total. The rest was mined from land, the surface of which showed no coal.

COMPRESSED AIR AT PANAMA.

One of the largest air-compressor plants in the world is that which supplies compressed air for the work on the Panama canal. Of the four separate stations, the one at Empire is the largest and the one at Balboa the smallest. The other two are at Las Cascadas and Rio Grande. The air compressors at Las Cascadas, Empire and Rio Grande deliver their entire output into a 10-inch main, 14 miles long, from which it is drawn off by smaller subsidiary mains to the air drills and other machinery at various points along the canal. The greater part of the air is used in and around Culebra Cut. The plant at Balboa comprises two Laidlaw-Dunn-Gordon compressors, each capable of delivering 2,200 cubic feet of air into a main four miles long. The two plants thus have 18 miles of air-compressor mains, which is believed to be the longest in existence.

AN EXERCISE IN LABORATORY ASTRONOMY.

By J. E. Gould.

The Equation of Time.

The determination of time is one of the most important problems in astronomy. Standard time, the time kept by most clocks, is the mean solar time at a certain meridian.

For examples: Eastern Standard Time is the mean solar time at the 75th meridian west of Greenwich; Central Standard Time is the mean solar time at the 90th meridian.

This exercise has to do with the difference between mean solar time and true solar or apparent time.

The equation of time, which in reality is not an equation at all, according to the general meaning of the term "equation," is an interval of time, the difference between mean solar and true solar time. It is the correction which must be added algebraically to true or apparent time in order to get mean time.

Since apparent time is defined as the hour angle of the apparent or true sun, and mean solar time is defined as the hour angle of a fictitious, or mean sun, moving uniformly in the equator, the equation of time may be defined as the difference between the two hour angles. It is equal also numerically to the difference between the two right ascensions.

The necessity for the equation of time arises from the fact that the apparent motion of the sun is irregular and no clock can be constructed to keep apparent or sun dial time.

This irregular motion is due chiefly to two causes: First, the apparent sun moves in an ellipse according to the law of areas.

Second, the plane of the path of the apparent sun is inclined to the plane of the equator, or, stated in another way, the plane of the ecliptic is not perpendicular to the axis of the earth.

All the other causes of irregularity combined amount to only a few seconds.

Consideration of the First Cause.

Kepler's First Law is: The orbit of every planet is an ellipse with the sun at one of the foci.

The Second Law is: Every planet moves so that the radius from the sun sweeps over equal areas in equal intervals of time.

It is evident from these laws and Fig. 1, that the arcs moved over by the earth in its orbit in equal intervals of time are unequal. In other words, the velocity of the apparent sun is not uniform.

That part of the equation of time due to the variable *velocity* of the apparent sun will be called E. It will be the difference

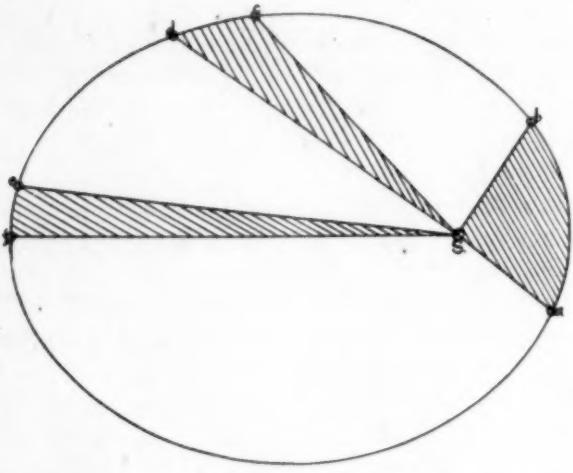


FIG. I. EQUAL AREAS IN THE SECTORS BUT UNEQUAL ARCS.

between the hour angle of the apparent sun and the hour angle of a mean sun, called the dynamical mean sun, moving at a uniform rate in the *ecliptic*.

The dynamical mean sun moves round the ecliptic in the same

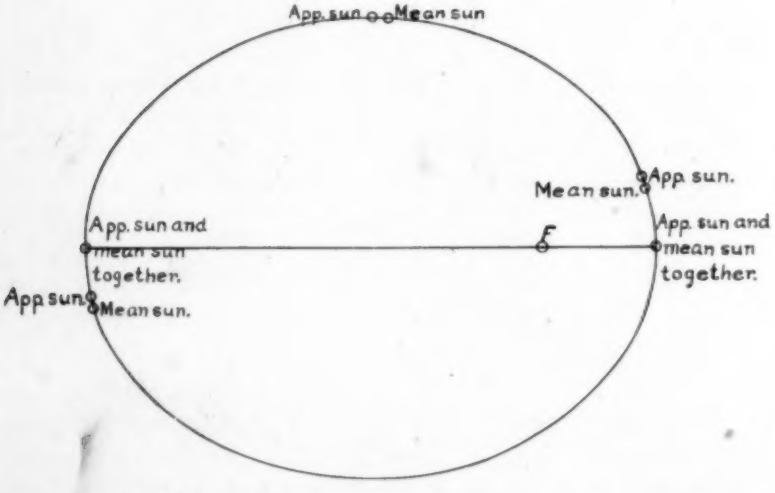


FIG. II. RELATIVE POSITIONS OF APPARENT SUN AND DYNAMICAL MEAN SUN.

period as the apparent sun. The two suns start out together at the perihelion point.

By this arrangement therefore, the inequalities due to the unequal motion of the apparent sun in the ecliptic are removed.

Referring to Fig. II, on December 31st, the apparent sun and dynamical mean sun are together at perihelion and E equals 0. At the perihelion point the apparent sun is moving with its maximum velocity and it leaves this point ahead of the dynamical mean sun.

The apparent sun remains ahead of the mean sun until the aphelion point is reached, where the two coincide and E is again zero. From aphelion the apparent sun is behind the mean sun until perihelion is reached, where E is 0.

From perihelion to aphelion, the hour angle of the dynamical mean sun is always greater than the hour angle of the apparent sun. Therefore in this interval E is positive.

By computation it is found that the maximum difference is about 7 minutes, Barlow & Bryan, Mathematical Astronomy.

This difference cannot be computed by elementary methods.

From aphelion to perihelion the hour angle of the dynamical mean sun is always less than the hour angle of the apparent sun. Therefore in this interval E is negative. The maximum difference is the same as for the other half of the orbit.

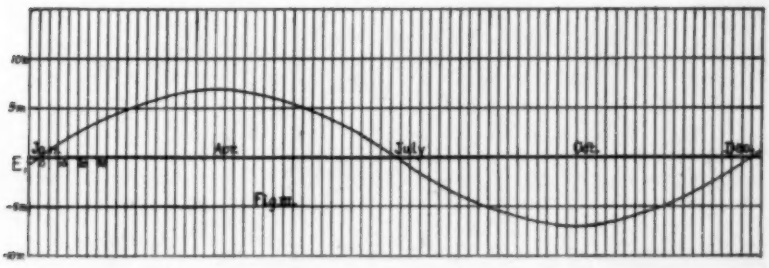


FIG. III. GRAPHICAL REPRESENTATION OF THE CHANGE IN E, AS THE APPARENT SUN MOVES FROM PERIHELION AROUND TO PERIHELION AGAIN.

The perpendicular distance from the base line to the curve gives the value of E, on the corresponding date.

We have now the correction necessary to change from the time of the apparent, or true sun, to the time of a mean sun, the dynamical mean sun, moving uniformly in the ecliptic.

CONSIDERATION OF THE SECOND CAUSE.

Although the dynamical mean sun moves uniformly in the ecliptic, its hour angle does not change uniformly because of the obliquity of the ecliptic.

That part of the equation of time due to the obliquity of the ecliptic will be called E_2.

E_2 will be the difference between the hour angle of a mean sun, called the astronomical mean sun, moving uniformly in the equator, and the hour angle of the dynamical mean sun moving uniformly in the ecliptic.

Thus we have introduced the motions of two mean suns into the problem.

The two mean suns start together at the vernal equinox, and since they both move uniformly, one in the equator, and one in the ecliptic, their hour angles are equal at the equinoxes and solstices. At these points E_2 is zero.

But at intermediate points, between the equinoxes and solstices, the two suns would not be on the same hour circle.

If in Fig. IV, we mark on the ecliptic a point, Sd.m., halfway between the vernal equinox and the solstice, and a point, Sa.m., on the equator, 45° from the equinox, it will be seen that the point Sd.m. is west of the point Sa.m. In other words, the hour angle of Sd.m. is greater than the hour angle of Sa.m.

Therefore E_2, which is equal to the hour angle of Sa.m., the

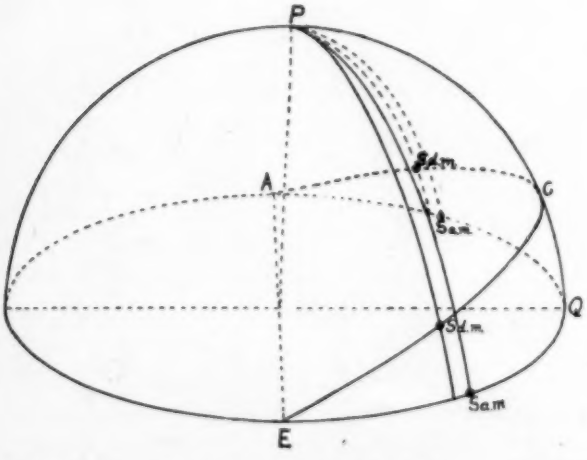


FIG. IV. RELATIVE POSITIONS OF DYNAMICAL MEAN SUN AND ASTRONOMICAL MEAN SUN.

astronomical mean sun, minus the hour angle of Sd.m., the dynamical mean sun, is negative.

This difference, which is the maximum obtained, is nearly ten minutes. It occurs successively half way between the equinoxes and solstices. See Barlow and Bryan, Mathematical Astronomy.

Again in Fig. IV, if we mark the point, Sd.m., on the ecliptic half way between the summer solstice and the autumnal equinox, and a point Sa.m. on the equator 45° from the solstice, it will be seen that the point Sd.m. is east of the point Sa.m. In other words, the hour angle of Sd.m. is less than the hour angle of Sa.m.

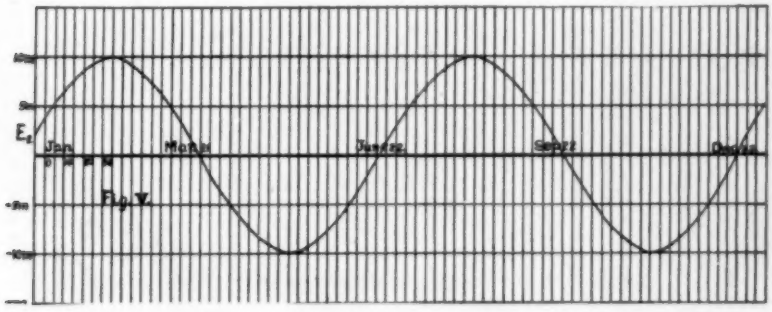


FIG. V. GRAPHICAL REPRESENTATION OF THE CHANGE IN E_2.

Therefore E_2 is positive.

From the autumnal equinox to the winter solstice E_2 is negative, and from the winter solstice to the vernal equinox E_2 is positive.

In Fig. V a graph of the variation of E_2 is shown.

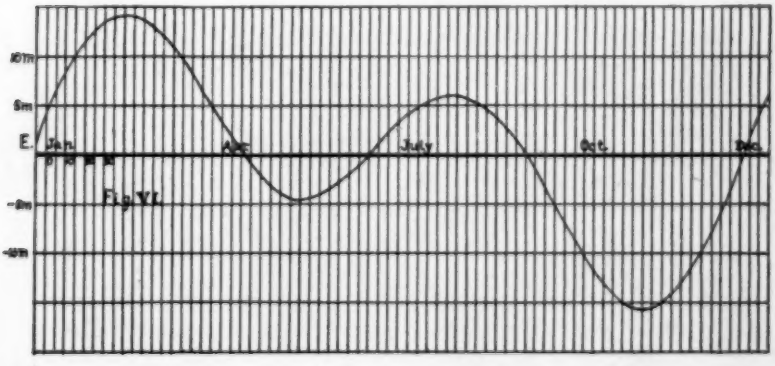


FIG. VI. GRAPHICAL REPRESENTATION OF THE EQUATION OF TIME.

It is easy now to draw a graph of E, the equation of time, $E=E_1+E_2$.

In Fig. VI the perpendicular distance from the base line to the curve at any point is equal to the algebraic sum of the perpendiculars at the corresponding points of the curves for E_1 and E_2.

This resultant curve cuts the horizontal axis four times. At these points E is zero. Therefore the equation of time becomes zero four times a year.

The largest variations in the equation of time occur in the autumn and winter. During spring and summer the variations are small.

The equation is zero about April 16th, June 15th, September 1st and December 25th.

The maximum values are:

$+14^m\ 27^s$ on February 11th.
$+\ 6^m\ 17^s$ on July 26th.
$-\ 3^m\ 50^s$ on May 14th.
$-16^m\ 21^s$ on November 3rd.

WORK FOR MONEY BUT STAY IN SCHOOL.

They do not allow working to interfere with going to school in Hammond, Ind. Special arrangements are made whereby boys and girls may work half a day in certain commercial establishments and attend school the balance of the day. Hammond is a manufacturing community, where the temptation to boys and girls is strong to leave school and earn a living. Supt. McDaniel's plan makes it possible for boys and girls to earn money, remain in school, and also make themselves more efficient industrially.

The plan at Hammond is based on a full realization of modern social and industrial conditions. Supt. McDaniel proceeds on the theory that, while there are certain general principles underlying all education, each community has its own special problems that are too often disregarded in the making of the schools. Besides the coöperative school and shop arrangement, Hammond maintains a night school with an attendance of 700, where boys and girls may not only make up elementary deficiencies, but also receive practical training in specific phases of commerce and industry.

Vocational guidance forms another feature of the Hammond plan. The schools furnish information about the various industries in the community, the salaries paid in different lines of work, the opportunities for advancement, hours of labor, permanency of employment, and all the details that are of value in determining a choice of employment. As early as the sixth grade the teacher tests the child's interest and ability in various forms of elementary industrial work, so that he may come to have some idea of a future vocation. The school authorities also maintain an employment bureau, where present and former pupils are registered and their qualifications carefully investigated.

PHYSICS FROM THE GIRL'S POINT OF VIEW.*

By Adele Cazin

Montclair State Normal School, N. J.

The ever present problem to the physics teacher is, or should be, to make the physics taught a vital matter to the pupil. Statistics show that physics is not elected by a large number of high school pupils in schools where this subject is elective. Its popularity has decreased rather than increased in recent years. It is to be noted also that it is elected less frequently by girls than by boys. This means of course that girls have discovered, or think that they have discovered, that the physics taught in the average high school is not vital to them.

To the question put to girls who enter the Normal School, "Why did you not study physics in your high school course?" the answers most frequently given are, "Had no time on my program." Apparently everything else was more important! or, "They just weighed and measured and worked problems all the time and I did not care about that." Surely there is nothing inherent in the nature of either girls or physics which should make them incompatible. What a pity that every girl, every future home maker, does not have a course in practical physics. Who needs it as much?

The question which I wish to bring before you is, "What material should be presented under the head of physics so that every girl will feel her need of such a course?" I am going to confine myself largely to a question of selection of material, although the question of method is equally as important.

That the interest and activity of girls along this line can be aroused has been proven. Where then is the trouble? Is it not that there is so much material taught under the head of physics which makes no appeal to the average girl? The larger portion of what is usually taught under the head of mechanics bears no relation to her life. "What?" I hear someone saying, "Teach physics without its backbone, mechanics? Impossible!" I say "Why not in a girls' course introduce only such points in mechanics as are essential to the comprehension of the practical problems which she needs to solve?" I note that Miss Littell, in the November number of School Science and Mathematics, makes the same suggestion. After all, do such things as dynes and ergs mean anything to a high school girl, no matter how

*Read before the Physics Club of New York, December 7, 1912.

glibly she may define them or how readily she may work problems founded on them? Someone is saying, "Oh, I see, physics from the girl's point of view means easy physics." No, it does not. Whether the material presented is difficult or easy, provided that it is within the comprehension of the student, is not a vital question. Girls are not afraid of hard work and, on the average, have almost as much grey matter as the boys and frequently make up the deficit by greater application. They do not want to be pampered. To make for them a snap course is not the aim in view, and would not be the result, of the proposed changes, critics to the contrary.

I hold that neither boys nor girls want to study a subject simply because it is easy or difficult. They do not make the sad mistake of the believer in the formal disciplinary value of education, of feeling that just because a subject is difficult it is beneficial. The American girl, as well as the boy, has some very sound ideas on the subject of education and practically applies them when making her selection of subjects. Is it not time for the teacher also to do away with the notion that physics owes its place on the curriculum to its disciplinary value? We no doubt all agree that there is scarcely a subject that can compare with it in content value. Surely not Latin or algebra or geometry! Are these subjects not made compulsory because the majority of educators are laboring under the formal disciplinary delusion? Why is physics made an elective? Surely its content value entitles it to rank as a required subject. But we physics teachers fall readily into the trap set for us, and, instead of making the physics we teach valuable because of its content, we endeavor to turn it into a branch of mathematics, and cry aloud against snap courses in physics when any one assails our content. How these critics berate the pernicious practice of giving a course in physics to future homekeepers which does not spend considerable time and energy on formulas for finding the velocity, etc., of freely falling bodies and the kinetic energy of suppositious cannon balls in motion. Of course anyone who is a specialist in physics finds such subjects interesting and valuable, but is their place not in the college for the student who elects physics on account of special aptitude, and not in the high school for the great body of students who will derive no benefit from such material?

To summarize, the argument in brief runs thus: the formal disciplinary conception of education is false, therefore the only

excuse for the presence of a subject in the curriculum is its practical content value. No material should be included under the head of physics, or any other subject, which does not have content value. Content is only of value if it directly touches on the life, the experience, of the student. The function of this material should be to throw new light and to enlarge ideas on experiences with which the pupil is already familiar.

In the selection of material it is necessary to keep the aim to be accomplished definitely in mind. I feel that one of the important purposes of physics teaching is that every girl shall get a real conception of the universe as a place of law and order. Somewhere in the course she must be introduced to various fundamental conceptions, such as the laws of gravitation, inertia, etc. She should get the tingle that comes from really understanding how the earth and other planets manage to ceaselessly fall around the sun. Such ideas, I hold, help to give a large outlook that may save her from being overwhelmed by the trivialities of life. Such, I therefore hold, is essentially practical and must not be sacrificed for reading of meters or wiring of bells, although the practical from that point of view should also have its place.

Of course the great laws must be taught from the point of view of their applications, or they will mean nothing. But the girl who learns about the law of inertia in taking up the problem of how to step off a street car correctly, should not stop there, but should see what part the force plays in preventing chaos in the universe. While in many schools the pendulum of reform has not begun to swing towards the practical, in some there is danger of its swinging too far in what appears to be the practical direction. There is considerable danger of working out so-called practical problems, which, after all, are not so. To choose wisely is a difficult matter and no teacher can hope to succeed in every case, but the attempt is both interesting and well worth while.

The ability to diagnose a piece of apparatus, as Prof. Woodhull has aptly put it, seems to me a legitimate practical aim. The ability to appreciate the value of a fireless cooker or a thermos bottle, or the ability to buy an electric iron to fit conditions, or to reject a filter because the underlying scientific principle is understood, is certainly of value. If a girl understands the kitchen boiler, gas range, electric devices, ventilation and heating of her home and the plumbing system sufficiently to know when

she needs to employ a plumber and when the problem is simple enough for her own solution, and other similar problems, she will have plenty of real solid work to do. Why annoy her by making her do such stunts as finding the weight of a body by balancing it on a fulcrum and considering the weight as concentrated at the center of gravity? She will never use that method to find whether the grocer is sending her short weight in sugar. Better give her the ability, by training her into the habit of seeing through things, to see of her own accord, without having anyone point it out to her, such things for example as, that the store which keeps a heavy object on the scale pan of the spring balance when it is not in use, is stretching the spring and giving false weights. The battle against false weighing should be carried on by the housewives, and never will be won until they are intelligent on the subject. Get the girl into the habit, if you can, of seeing through the physics of her daily environment and she will manage very well without much of the material now presented. I am not arguing for a choppy, unrelated study of various devices. There should be in my opinion, systematic study of heat, light, sound, liquids, the atmosphere, magnetism and electricity and the incidental mechanics. But such phases of these subjects should be chosen as can readily be seen to have direct relation to some aspect of a girl's life. The practical problem must be the basis of selection.

I will not attempt to present the outline of a course based upon this fundamental principle. Each teacher with this principle in mind can outline such a course and will want to do so. As conditions differ so greatly in various localities no outline prepared by one teacher can fully meet the requirements of any other, although such outlines may be suggestive. Individual differences of opinion on the part of the teacher will determine the starting point. I should want to begin with the ever and everywhere present, intensely interesting, ever to be reckoned with, force of gravitation. The topics of equilibrium, inertia, centrifugal force, touch the girl's life in so many ways. How to stand up easily in a moving car! How to use an escalator comfortably! Why not to change seats in a boat by both standing up at the same time! How to make toys that will not fall over, for the delight of the baby! All these and a hundred other problems can be solved by the girl herself from the point of view of the underlying scientific principle, and the girl will respect both the science and the everyday experience all the more when she realizes their connection.

I should have her, with every topic, get some of the inspiration that comes from studying great achievements by devoting some time to the consideration of the great scientists. Newton with gravitation, of course. What a pity to study one without touching on the life of the other! Such biographical work, assigned in the form of special topics, gives an opportunity for individual effort that is very beneficial.

I should wish to have a fairly large share of the time devoted to heat, which is so intimately related to life in every way. I should spend no time on having a girl find the linear coefficient of expansion of a metal. Why should she? I should consider it better to have her note the unequal expansion of two metals riveted together and apply her knowledge to the understanding of the thermostat, metal thermometer, etc. I do not hesitate in saying that I would reduce the amount of quantitative laboratory work and increase the qualitative. Girls as well as boys nearly always have the desire to fully understand. Sometimes mathematics is necessary to such complete comprehension, as in studying specific heat. Even there I would simplify the problem as much as possible so as not to hide the issue, a thing which, I fear, mathematics often does for the high school student. After all, the order in which the material is taken up is not a matter of great consequence. The important thing, I repeat once again, is that such material as cannot be shown to have a bearing on the life of the girl should be discarded. Perhaps girls will want to study physics when this comparatively simple desideratum has been fulfilled. Difficulties may stand in the way. Are they unsurmountable? Surely the attempt seems worth while.

The Twenty-third Report of the Missouri Botanical Garden (Shaw's Garden) is the first from the new director, Dr. Moore. It appears that this very important botanical institution now has under cultivation 12,688 species and varieties of plants. Its herbarium includes 698,706 herbarium specimens, and its library, 69,915 volumes. Fifty-one students have been under instruction in the undergraduate department. The master's degree in botany has been conferred on five candidates and the doctorate upon one during the year.

Seven scientific papers are included in the volume.

MAKING HIGH SCHOOL PHYSICS REAL.*

By F. F. Good,
Columbia University.

There is a great demand at the present time for the teaching of real things in the high school. The whole educational machine, in recent years has fallen under criticism from within and from without; and in almost every branch of the course we have witnessed a very commendable effort to readjust the work of the public school to meet the more immediate needs of every day living. This humanizing movement, as it is related to the physics course is an attempt to make physics more practical, more real,—I dare say more popular with the average student and indeed more profitable. The high school physics of the future is to be a course for the many and not for the few. It is not to be a preparation for a specific kind of advanced physics but it is to be an educational unit, complete in itself.

John Dewey has maintained that, "The business of the high school is, primarily, a social business, not of creating a class of specialists." Under a broad social definition of high school instruction and in the light of the modern educational practice, many teachers have joined in a movement to make physics more practical. It is an effort to abandon the more formal and disciplinary physics teaching and to replace it by a study of those mechanisms, appliances and phenomena which offer a stronger motive and which are more closely related to life. It is a movement of opposition to abstraction, bookish ideas and generalities in education and it seems to have come upon us with compelling authority.

A brief review of the lives of the great men of physics will suffice to show, in a striking way, how few of them received their early training in anything like our conventional physics course. On the other hand, it is proverbial how the great scientists of the past devoted their boyhood hours to pondering over the practical problems of real appliances.

From his early childhood Galileo had shown the greatest talent for mechanical invention, his wonderful toys and little models of machinery being the admiration and delight of his companions.

Sir Isaac Newton devoted much of his leisure time to constructing machines, water-clocks and sun-dials and from these

*Paper read before the New York State Science Teachers' Association, December 27, 1912.

amusements he is said to have developed a sense of observation and accurate reasoning.

Cavendish began his experiments in a stable and here, in the crudest possible fashion, he carried out many of his experiments, including those electrical investigations which forestalled so much of the work of the past century.

Count Rumford was apprenticed to an importer and merchant and during business hours he would occupy his spare moments with mechanical contrivances which he used to hide under the counter.

Faraday while apprenticed to a book-binder was engaged in experiments with voltaic batteries of his own construction. Having cut out seven discs of zinc the size of half-pence, he formed a pile by inserting pieces of paper soaked in common salt between each pair and found that the pile so constructed was capable of decomposing Epsom Salts.

As a child James Clerk Maxwell was never content till he had completely investigated everything which attracted his attention such as the hidden courses of bell-wires and water streams and the construction of all sorts of mechanisms. His constant question was "What's the go of that?" Maxwell did not profit much by the ordinary teaching of the schools.

These instances and many other similar ones show that almost invariably, the first-hand study of practical appliances and life's experiences go hand in hand with the growth of scientific enthusiasm and scientific genius. This method of education affords an interesting contrast with the formal dignity of the customary text-book and the thirty-five or forty quantitative experiments in the laboratory. Five years ago, Professor Franklin of Lehigh University said, "I believe that the physical sciences should be taught in the Secondary School with reference primarily to their practical applications. The text-books should be devoted chiefly to the description and analysis of the more familiar practical applications of physics and accompanied by many illustrations of actual devices; and the laboratory work should be of a character suggested above. Such a course would be of the greatest value to young men who do not enter college and it would furnish a most satisfactory basis for college work in the physical sciences."

A second factor in the demand for the study of reality in high school physics arises as a result of social pressure from outside the school. The public is coming to demand a practical physics

course. The average man seldom finds an opportunity to express his views on educational affairs in a public way. Occasionally we find his criticism in some obscure corner of the daily paper. He is not interested in such academic discussions as the nature of the all-pervading ether; but he applauds loudly when he sees the public school attempt to fit the child for the more immediate needs of every-day life. The average man prefers for his children a type of education that minimizes the importance of the study of abstractions and he heartily favors an educational program which aims to prepare for the problems of life. Public opinion may indeed be narrow in matters of education but, nevertheless, the public reserves the right to ask, "What is all this expenditure of time, money and nerve force worth?"

The investigations of educational experts constitute a third factor in the demand for the teaching of practical applications. It is rather interesting to note that physics is perhaps one of the last subjects of the school course to submit to the readjustments of modern educational method. Language, mathematics, history and geography have all grown less formal in treatment within recent years. The comedy of the situation is that physics was not aroused from her orthodoxy till students began to blacklist the course.

Commenius, one of the first educators of modern times who dared to champion the cause of scientific method embodied in "The Method of the Sciences" this principle, "Whatever is taught should be taught as being of practical application in every-day life and of some definite use." Pestalozzi's whole teaching was in opposition to the prevailing education in generalities, "When men rush into the labyrinth of words, formulas and opinions without having gained a progressive knowledge of the realities of life, their minds must develop on this one basis and can have no other source of strength."

"The best single guarantee of close and continuous attention," says Professor F. M. McMurry, "is a deep, direct interest in the work in hand, an interest similar in kind to that which children have in play." "Broad general aims cannot generate this interest for abstractions do not arouse enthusiasm. It is the concrete, the detailed that arouses interest, particularly the detail that is closely related to life."

In this connection Professor Dewey says, "Unless we master things we shall continue to be mastered by them. The magic that words cast upon things may indeed disguise our subjection

or render us less dissatisfied with it, but, after all science not words casts the only compelling spell upon us."

In the past a great deal of time has been devoted to grounding students in abstraction in the hope that the vast realm of applications and experiences would fall naturally into their appointed logical places. Occasionally this deductive approach to physics succeeds in converting a human mind into a scientific encyclopedia, but it does not contribute toward independent scientific thinking.

The study of reality as against abstraction will form a true basis on which to build scientific concepts. The study of experiences and appliances will not only inspire enthusiasm and sustain interest, it will provide a scientific procedure in thinking and, in addition, it will equip the students with an intelligent interpretation of his physical environment. At this point I want to add also that any teacher who succeeds in carrying into operation such a teaching program and does it well does not need to "sugar-coat" the physics course; he is not teaching "kindergarten" physics; he is performing a Herculean task fit for the commendation of the gods,—for he is the guardian of the growing mind on the difficult and untrodden path toward effective, independent thought.

To illustrate a practical procedure in physics study let us take such an appliance as a clock. Each student may be given the parts of a clock designed especially for construction work. Its movements may be readily taken apart and assembled and it includes all of the essentials of a commercial clock; the pendulum, the escapement, the series of cogs, the drive weights and chain and the rachet wheel. It keeps good time and may be accurately regulated by sliding the disc on the pendulum rod.

Such a clock affords a series of profitable studies in applied physics which may be extended to meet the needs of different classes. For example, after the actual experience of assembling the parts we may determine how long the clock will run with one winding; we may weigh the drive-weight and determine how much work is required to run the clock one day or, as a matter of curiosity, we may determine the horse-power of the clock in action; by suspending two clocks side by side and by sliding the pendulum disc or by attaching additional weights, we may study the laws of the pendulum. We may explain why the hour hand moves one-twelfth as fast as the minute hand.

After these exercises students will be more inclined to investigate clocks and they will inquire into the operation of related

mechanisms. They will study the movements of different types of clocks and watches; and some will venture to usurp the role of the clock-maker in the work of repairing.

Why should it be necessary for a physics student to pay fifty cents to have his watch regulated when he can push a small lever with a pen knife and regulate it himself?

The study of clocks may be continued in the form of an excursion to a large tower clock if one is available. Here, perhaps, we may study the advantage of a combination of pulleys carrying a weight of four hundred pounds; we may determine the indicated weight from the force applied at the crank in winding; we may see a seconds-pendulum in operation and observe many devices for insuring extreme accuracy. We may determine how much time is required for the tower clock to run down and how much work is required to wind it.

The study of such appliances will not only bring the student into vital contact with real things but it will also open the way for a repetition and review of many fundamental ideas in the study of mechanics. The customary treatment of mechanics in the high school has met with results of very doubtful value for the great majority of students; and it is hoped that a well-planned study of appliances will be found to have for its basis the soundest teaching principle and will prove to be much worth while for purposes of general education.

As a second illustration let us begin with a pump. In a laboratory exercise each student may construct simple forms of lift-pumps and force-pumps, using Argand lamp chimneys, a flask and appropriate rubber stoppers, rubber tubing and glass rods with small pieces of sheet rubber for valves. Any laboratory may have as part of its equipment a common kitchen pump listed at two or three dollars in the catalogue of Sears, Roebuck & Co., Chicago. This can be mounted so that it may conveniently be taken apart for examination.

A commercial form of hydraulic ram may be purchased and installed in the laboratory for demonstration at a cost of eight or ten dollars and may be used to illustrate a wide variety of the phenomena of mechanics. Or, perhaps, it would be better, first to construct a working model of a ram using a large T-tube, a flask, a test tube, and a small bottle as plunger with a large glass tube as supply pipe.

Here again students will profit richly by an excursion for the purpose of studying pumps. In Teachers College we have all

sorts of steam power pumps with the essential parts, cylinder, piston and valves,—compression pumps, vacuum pumps, pumps for forcing water for various purposes, pumps for operating hydraulic elevators. Indeed a steam engine is a pump working inversely.

A visit to the city pumping station will constitute an essential part of the work and will open the way for a further study of water systems, pressures and appliances.

EDUCATION THAT PAYS ITS OWN WAY.

"Industrial work in the schools of Gary, Ind., made money instead of costing money during the past year," says Dr. P. P. Claxton, United States Commissioner of Education. "When the school authorities in Gary came to sum up the results of the work in the trade courses, they found that the three departments of printing, cabinet work, and painting, had to their credit a profit of $875.48. This is real value, too; the pupils made articles that were needed in the school; if they had not made them in the school shops the authorities would have had to purchase them in the open market at a total price of seven or eight thousand dollars."

The Commissioner then gives the figures for each of the trade classes in the Gary schools, as reported by G. E. Wulfing, in charge of the industrial instruction. In the printing department the value of the work produced was $1,972.92. The salary expense was $1,483.49 and supplies cost $314, leaving a net balance in favor of the shop of $175.43. There were 35 in the printing class, so instead of figuring the per capita cost of the industrial training of these pupils, it was possible to figure a definite contribution by each pupil to the wealth of the community.

"In the cabinet department," says Dr. Claxton, "the product was valued at $3,608.85, and the expense was $3,155.37, leaving a balance of $453.48 in favor of the carpenters. Similarly, the painting department of the school showed a 'business' of $1,591.25 and an expense of $1,344.73, or a clear profit of $246.52.

"Gary's conspicuous success with industrial training is an interesting indication of the spread of the modern movement for vocational education, which insists that in addition to teaching the recognized branches the school must give instruction in those subjects that are of most immediate value to the community which supports it. In Gary the dominant interest is trade education; in rural districts it is largely agriculture; in the cities it may be stenography, typewriting, and other commercial branches. In any case, it is coming to be felt more and more that an educational system is incomplete that fails to provide vocational training for its citizens."

AMERICAN GEOMETRY IN FRANCE.

By George Bruce Halsted.
Greeley, Colo.

For the first time, an American geometry has been translated into French and published in Paris. What the French authorities think of it is of deep interest to America. Says Professor A. Buhl of the Faculté des Sciences de Toulouse: "This treatise on geometry, admirable for simplicity and rigor, is a work of the first rank, that professors, students, and lovers of mathematics will take up to read and will read to the very end, because, despite some inevitable neologisms, it is absorbingly interesting.

"Its publication is most opportune, since routine is getting the upper hand and threatens to paralyse the efforts of the Mérays, Bourlets, and Borels to revivify the teaching of geometry in France."

In the *Revue des Sciences,* 15 Mai, 1912, p. 360, we have, by Gérard,

"Halsted (G.-B.).—Géométrie rationnelle. Traduit par M. P. Barbarin, avec une preface de M. Laisant. Gauthier-Villars, éditeur.

"Halsted establishes the theorems of geometry without using the circle, the Archimedes assumption or any principle of continuity. Metrical geometry as expounded in French works seems to rest upon the notion of fractional and irrational number. This is a blunder. Euclid based it upon the assumption afterward stated by Archimedes and now named for him. But Halsted shows even this assumption unnecessary, and without it establishes metrical geometry and the theory of areas. So two facts are striking and memorable: the one, entirely new, that metrical geometry is a mere prolongation of what we French call the first book; the other, already known, that the notion of area is wholly a construct."

But on the same date *L'Enseignement mathématique* finds two quite other facts most striking. "The two things which have most struck me are, on the one hand, the introduction of the sect calculus, which, once defined, gives the whole theory of similitude, and, on the other hand, the constructions, all accomplished, without the compasses, solely by aid of the sect-carrier. This instrument reduces to a mere visiting card on whose edge are marked off the sects to be carried.

"The constructions so effected are eminently interesting and certain of them are marvels of ingenuity. Henceforth the use of the compasses, that is to say of the instrument which traces a curve to solve problems about straights, appears almost shocking from the logical point of view. From the view-point of the order of things, the sect-carrier will be the instrument fundamental and unique of the sect calculus.

"For the study of volume, the theory of the prismatoid dominates everything; the round bodies, even the sphere itself, are compared to solids with plane faces."

GENERALIZATION AND APPLICATION OF THEOREMS IN GEOMETRY.

By Philip Fitch,
Denver, Colorado.

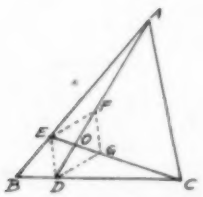
It has been the experience of the writer that nothing adds more to the interest of the study of geometry than a variation in the proof of the theorem which is being studied. Getting away from a hard and fixed proof, passing to the generalization, and making application of some definite theorem causes the pupil to discover and appreciate the beauties of the science. The following is one case which the present writer has worked out.

Theorem. The medians of a triangle are concurrent in a point which is two-thirds the distance from each vertex to the mid-point of the opposite side.

Let ABC be the given triangle, and CE, AF, and BD be the medians. Draw AB′ parallel and equal to BC. Join B′ to C.

ABCB′ is a parallelogram. Since ADC is a diagonal, BDB′ is also a diagonal. Join C to F′, and mid-point of AB′; and join A to E′, the mid-point of CB′. AF and CF′ trisect BB′; and CE and AE′ trisect BB′. Therefore AF, BD, and CE are concurrent. BO=1/3 BB′. BD=1/2 BB′. Therefore BO=2/3 BD. In like manner, CO and AO may be shown to equal two-thirds of CE and AF respectively.

Generalization.

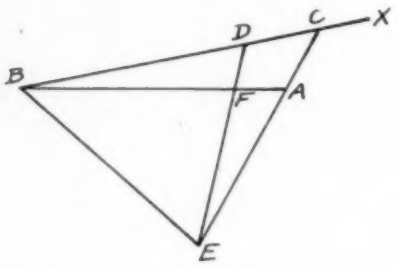


In the ΔABC take $BD=1/nBC$ and $BE=1/nBA$.
Draw CE and AD and let them intersect at O.

$$OD=\frac{1}{n+1}\ AD \text{ and } OE=\frac{1}{n+1}\ CE.$$

This may readily be obtained from an application of Ceva's theorem. It may also be obtained by drawing the parallelogram EDFG.

APPLICATION.



To divide a line into n equal segments.

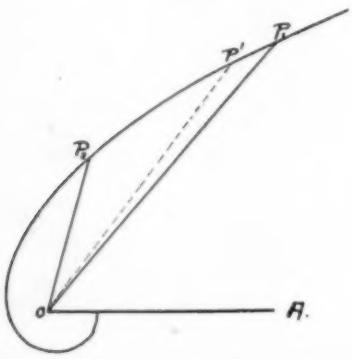
Let AB be the given line.

Draw BX, maying any convenient angle with BA, and from B with any convenient unit lay off on BX n—1 equal parts, the last point of division being at C.

Draw CE through A, making CE=n—1 times CA. Join E with D, the next to the last point of division on the line BX, and let this line cut AB at F. AF equals $1/n$ AB. Lay off AF on AB n times. From a consideration of the above generalization the proof may be readily seen.

AREA OF THE HYPERBOLIC SPIRAL BY ELEMENTARY METHODS.

OTTO J. RAMLER,
Professor of Mathematics, Canisius College, Buffalo.



Let P_1 and P_2 be any two points on a given hyperbolic spiral, O the origin, and OA the initial line. Let $OP_1 = r_1$, $OP_2 = r_2$. Call angles P_1OA and P_2OA, θ_2 and θ_1 respectively. Then by definition of the hyperbolic spiral we have $r_1 = \frac{K}{\theta_1}$, and $r_2 = \frac{K}{\theta_2}$ where K is the factor of proportionality. Divide angle P_2OP_1 into m equal parts, and let P_1OP', $P'OP''$ $P''OP'''$ . . . $P^{m-1}OP_2$ represent these equal parts. Draw the chords P_1P', $P'P''$, etc.

Then by trigonometry, the area of any one of these triangles is $\frac{1}{2}$ OP^i. OP^{i+1}. sin (POP^{i+1}).

Or letting δ represent the sum of the areas of the triangles, and $r^i = OP^i$,

$$\delta = \tfrac{1}{2}[r_1 r' + r' r'' + \ldots r^{(m-1)} r_2] \sin \delta \quad \text{where } \delta = \frac{\theta_2 - \theta_1}{m} = \text{angle } P' O P^{t+1}$$

$$\therefore \delta = \frac{K^2}{2}\left[\frac{1}{\theta_1(\theta_1+\delta)} + \frac{1}{(\theta_1+\delta)(\theta_1+2\delta)} + \ldots + \frac{1}{(\theta_1+m\delta)[\theta_1+(m+1)\delta]}\right]\sin \delta$$

$$= \frac{K^2}{2}\left[\frac{m}{\theta_1(\theta_1+m\delta)}\right]\sin \delta = \frac{K^2}{2}\left[\frac{m}{\theta_1\theta_2}\right]\sin \delta.$$

If m becomes very large and tends toward infinity, the sum of the triangles approaches the area bounded by the spiral and the two radii vectores OP_1 and OP_2, and in our last equation sin δ becomes arc δ, and we have,

$$\text{Area} = \frac{K^2}{2}\left(\frac{m}{\theta_1\theta_2}\right)\delta = \frac{K^2}{2}\left(\frac{m}{\theta_1\theta_2}\right)\left(\frac{\theta_2-\theta_1}{m}\right) = \frac{K^2}{2}\left(\frac{\theta_2\theta_1}{\theta_2-\theta_1}\right)$$

$$= \frac{K}{2}\left(\frac{K}{\theta_1} - \frac{K}{\theta_2}\right) = \frac{K}{2}(r_1 - r_2) \text{ . Q.E.F.}$$

That is the formula obtained by the integral calculus. The area, therefore, is proportional to the difference of the length of the bounding radii.

CIRCASSIAN WALNUT.

The United States, says the Department of Agriculture, is probably the largest consumer of Circassian walnut, one of the world's best known and most expensive cabinet woods.

The high cost of Circassian walnut is due to the scarcity of the beautifully figured variety demanded for furniture and interior finish, for the tree itself is more widely distributed than almost any other of commercial importance. The demand for the best wood, however, has always outrun the supply. Even in the eighteenth century, when wars in Europe were frequent, so much Circassian walnut was used for gunstocks that the supply was seriously depleted. Early in the nineteenth century the wood of 12,000 trees was used for this purpose alone. Single trees, containing choice burls or fine bird's-eye figures have sold for more than $3,000.

The tree is native to the eastern slopes of the Caucasus and ranges eastward to the foothills of the Himalaya Mountains, from which it extends southward to northern India and the mountains of upper Burma. It has been widely planted in Europe and the United States, in this country under the name of English walnut. The wood grown here, however, has not the qualities demanded by the cabinet and furniture maker. Much of the Circassian walnut now used comes from the Black Sea and from other parts of Asia.

According to a circular just issued by the Forest Service the demand for Circassian walnut has resulted in the substitution of other woods. Our own red gum is often sold as Circassian walnut, and butternut is also similar in general appearance to the less highly figured grades. Many good African, Asian, and South American woods resemble Circassian walnut, though none possesses the magnificent figure, delicate tones, and velvety texture of the latter. The circular discusses the supply and uses of Circassian walnut, and those who wish to know how possible substitutes may be distinguished can learn from this circular the distinctive marks which the Government's experts have discovered.

BRIEF GENERAL HISTORY OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

By Charles H. Smith,

Hyde Park High School, Chicago.

In the spring of 1902 physics instructors from a number of schools met in Chicago to consider the organization of an association of physics teachers of the Central States. A committee of three was appointed, which after further consideration of the matter, called a meeting for the 7th of June. Twenty-five schools were represented at this general meeting, at which an association was formerly organized, a constitution adopted, and officers elected. The Thanksgiving recess and the spring vacation were selected as the times for holding meetings of the Association. Preparations for the next meeting were at once begun by the various committees with the result that the meeting held November 28th and 29th at Lewis Institute, Chicago, proved very successful as to attendance and interest.

In November of the same year at a meeting of the Mathematics Section of the Educational Conference of Academies and High Schools certain questions were considered, one, with reference to the possibility of improving mathematical instruction by the introduction of laboratory methods and the closer correlations with the other subjects of the curriculum, especially physics, and another, as to the possibility of forming an Association of Mathematics Teachers to co-operate with the Central Association of Physics Teachers. As a result, there was presented at the Thanksgiving session of the Physics Association a petition signed by the teachers of mathematics and of the high school sciences, asking that an organization of a larger association be considered, such an association to include sections of each of the sciences and mathematics. The petition was referred to the Executive Committee, and during the winter the Executive Committee and those of the petitioners most interested perfected plans to make the April meeting an organization meeting for the Central Association and to provide programs for the different sections. Meanwhile there was held on December 15 a meeting to consider more especially the question of laboratory mathematics. At that meeting the organization of the general association was perfected with biology, chemistry, earth science, mathematics, and physics sections. The constitution of the former Association was modified to meet the needs of the larger organization. The general

officers of the Physics Association were continued for the remainder of the year, and the Central Association of Physics teachers became the Physics Section of the new organization.

The meetings of the Central Association of Science and Mathematics Teachers are held during the Thanksgiving recess of each year. It has been the policy of the Association not to centralize its officers but to see that they are taken from all parts of the contributing territory. Two meetings have been held in the Northwestern University Building in Chicago, one at Armour Institute, Chicago; two at Lewis Institute, Chicago; one at the Central Young Men's Christian Association Building, Chicago; one at the University of Chicago; one at McKinley High School, St. Louis, Mo.; one at the Englewood High School, Chicago; one at Technical High School, Cleveland; and one, at Northwestern University, Evanston. It has been the policy of the officiary of the Association to hold the meetings in Chicago solely from the fact that Chicago being the most centrally located would be the most convenient place for the greatest number of those interested in the Association. The meetings have increased in interest and popularity from the beginning. Speakers from all parts of the country have been secured. The many phases of science and mathematical work have been studied and investigated. Exhaustive reports on the teaching of algebra, geometry, biology and earth science have been presented. A very complete report on the correlation of mathematics and physics in the secondary schools has been prepared and the Association is the father and promoter of the "New Movement in Physics Teaching." The American Federation of the Mathematical and Physical Sciences was first conceived by this Central Association.

The annual conventions have always been well attended by people from all states in the central United States. Papers presented have been of the highest worth. The Association together with its official Journal, has accomplished more than any other agency in raising the standard of secondary science and mathematics teaching.

For copies of SCHOOL SCIENCE, Vol. 1, No. 9, February, 1902, we will allow one year's subscription or pay $1.00 in cash.

HISTORY OF THE BIOLOGICAL SCIENCE SECTION OF THE CENTRAL ASSOCIATION.

By Otis W. Caldwell,
University of Chicago.

In the early days of the existence of the Central Association of Science and Mathematics Teachers, those who met to form the section of biology came together, not primarily because they knew what they wanted to do, but because they felt that they should be doing something that they were not doing. An indefinite reason for organization, we may say, but very real nevertheless, and a reason more or less commonly existent with teachers of other high school sciences. In the evolution of the high school curriculum, an evolution which like others in nature occurs somewhat blindly, sciences gained a place in the program. Science had grown so rapidly, its wonders and its commonplaces were now organized into fairly definite, though constantly shifting systems, its laboratory and its method had emphasized a new way of securing evidence and establishing truth—hence the conclusion that science must appear in secondary school programs. Preeminently biology, by means of which we study evolution; which deals with life; with the individual's and the world's food problems; with the struggle to live and to prevent oneself from being the food of other things that are also struggling to live; it must be important for secondary education.

But with biological science established in the school system, the teacher found himself "holding the bag," the elusive snipe not to be seen, and those who had planned the game having gone on about their business. It long ago became evident to biology teachers that it is one thing, a comparatively easy thing indeed, to enthuse over the beautiful systems of science and the value of learning by the scientific method, but quite a different thing to take a jar of preserved earthworms or *Spirogyra* plants, or textbook earthworms and *Spirogyra* plants, a roomful of sixteen-year-old children, and a few pieces of apparatus, and secure results that might honestly be called educative in a constructive way. Consequently, biology teachers organized in order that they might consider the problems that are involved in trying to use the biological sciences in educating secondary school children.

A study of the programs of the section reveals three types of activities: (1) the presentation of papers and discussions designed to inform teachers about recent advances in the sciences

concerned; (2) papers and discussions upon specific aspects of the teacher's difficulties; (3) attempts, (a), to organize our courses in biological sciences, and (b), to organize a critical study of the best practices in securing efficiency in our biological work.

There can be no doubt of the value to all biology teachers of the first type of activity of the biological section. Discoveries in biology come so rapidly that it is well-nigh impossible to keep abreast of the sciences included. At best most teachers can take only occasional excursions out into the periphery of our knowledge where they may view the advancing horizon of biological discovery. These excursions need to be conducted by leaders who feel sufficiently at home in the newer regions of biological science to enable them to give us proper perspective. While this first activity of the section is not its most important one, it is one of great importance, and should be continued in future meetings of the section. We are fortunate in having available research men, who are pleased to present the results of their research to the section from time to time.

The second type of activity strikes very close to the teacher's daily work. Special phases of the work are discussed, as laboratory equipment, nature and quantity of laboratory work, notebooks, how to use the text-book, the preparation and use of charts and lantern slides, etc. The topic "Field Work" may be taken as illustration. One section was given to a discussion of this topic, divided into: Field work with trees, birds, common weeds, insects, and fishes; each sub-topic being presented by a teacher conspicuously successful in teaching the topic assigned to him. In this connection, it should be especially noted that these topics were presented by teachers who have experimented in teaching the topics in question, and they have given us the results of their first-hand experiments just as truly as have the men who report their experiments in new fields of the science of their particular interest. The time is passing when the section cares to hear a speaker who has merely an untried theory regarding one of the problems of biology teaching.

The third type of activity is the most difficult to attack. It has produced some fundamental results, but it presents the most insistent demand for future work. We have decided upon underlying principles which, for a time at least, shall be the guides in determining our organization of courses and our practices in teaching. We have decided that biological courses in high school

should deal with those materials that will best stimulate and develop intelligent efficiency on the part of people who are going to deal with every-day affairs. But it is not enough to decide upon a working fundamental basis. We must proceed to study critically all phases of our materials and practices, and we must compare such studies. In short we must take a scientific attitude, not an empiric attitude toward the teaching of science. The section has had reports upon some such studies, and they serve to show how very potent a few facts about science teaching may be. We need during the next few years to make special effort to secure carefully planned, scientifically accurate studies of the relative efficiency of various phases of our work. The section may profitably serve as a center for organizing such studies and for distributing their results. This task is large and extremely difficult. It will require much time and there will be discouragements. But it is the logical step if we are ever to be really scientific in our teaching of the biological sciences.

NOTES ON "PEDAGOGY IN TRIGONOMETRY."

On page 118 of the February SCHOOL SCIENCE AND MATHEMATICS I note an excellent article by Dr. Baker of Brooklyn, N. Y. However I should like to take exception to his development on page 119. He remarks that

$$\sin (M+N) = \frac{a}{r},$$
$$= \frac{d}{r} + \frac{c}{r} = \frac{b \cos M}{r} + \frac{c}{r},$$
$$= \sin N \cos M + \frac{c}{4}.$$

So far all right, but now he goes on to change c/r and to my mind lapses back into what he is endeavoring to avoid. Why write $c/r = c/e \cdot e/r$. This form is confusing to the average student and is memorized by most. We can proceed as above in removing d/r, and adhere to the same method throughout; *i. e.*,

$$\frac{c}{r} = \frac{e \sin M}{r} = \frac{r \cos N \sin M}{r} = \sin M \cos N.$$

W. E. BECK.

Sioux City, Iowa.

I do not quite see the force of the words "lapses back" in view of the lines "but (alack) not sides of the same right angled triangle. The sides c and r belong to two different triangles whose common side is e."

Does not that supply a *motive* for introducing e?

Otherwise I think the criticism good, and the method suggested possibly preferable. My method adheres a little more to the idea of getting *neighboring lines* (lines in the same right triangle); possibly the other line of thought would be easier for the student.

Brooklyn, N. Y. A. L. BAKER.

ARTICLES IN CURRENT PERIODICALS.

American Botanist for February; *Joliet, Illinois; $1.00 per year, 25 cents a copy:* "In the Home of the Fan Palm," Charles F. Saunders; "The Cultivation of the Iris," Willard N. Clote; "The Mountain Spleenwort and Its Relatives," Willard N. Clote; "The Pelican Plant."

The American Mathematical Monthly for January; *Benjamin F. Finkel, Springfield, Mo.; $2.00 per year, 25 cents a copy:* "Foreword on Behalf of the Editor," E. R. Hedrick; "History of the Exponential and Logarithmic Concepts," Florian Cagori; "Errors in the Literature on Groups of Finite Order," G. A. Miller; "On the Remainder Term in a Certain Development of $f(a+x)$," R. D. Carmichael.

American Naturalist for February; *Garrison, New York; $4.00 per year, 40 cents a copy:* "Adaptation Through Natural Selection and Orthogenesis," Professor Maynard M. Metcalf; "Adaptation in the Living and Non-living," Professor Burton Edward Livingston; "Adaptation in Animal Reactions," Professor G. H. Parker; "Adaptation from the Point of View of the Physiologist," Professor Albert P. Mathews; "The Fitness of the Environment, an Inquiry into the Biological Significance of the Properties of Matter," Professor Lawrence J. Henderson.

Condor for January-February; *Eagle Rock, Los Angeles Co., Cal.; $1.50 per year:* "A Glimpse of Surf-birds (with five photos)," W. Leon Dawson; "Concealing and Revealing Coloration of Animals," Junius Henderson; "Swallows and Bedbugs," Edward R. Warren; "Notes on Some Fresno County Birds," John G. Tyler; "Bird Notes from the Coast of Northern Lower California," George Willett; "The Outlook for Conserving the Band-tailed Pigeon as a Game Bird of California (with map)," Joseph Grinnell.

Education for February; *120 Boylston St., Boston; $3.00 per year, 35 cents a copy:* "Progressive High School Reorganization," Ransom A. Mackie; "Effective Supervision," J. L. Stockton; "Training for Social Efficiency—'What Education Is For,'" Laura H. Wild; "Significant School Statistics," James E. Downey; "The College Boy," Harry Preble Swett; "The Training of the Industrial Teacher," Arland D. Weeks.

Educational Psychology for February; *Warwick and York, Baltimore, Md.; $1.50 per year, 15 cents a copy:* "Standards of Mental Efficiency," W. H. Pyle; "Mental Adaptation During the School Day, as Measured by Arithmetical Reasoning. Part II," W. H. Winch; "The Child's Speech. V. The Mastery of the Tongue," Robert MacDougall.

"L'Enseignement Mathématique for January; *Stechert & Co., West 25th St., N. Y.; 15 francs per year, 3 francs a copy:* "Henri Poincaré," A. Buhl; "Sur un cas particulier du problème de l'élimination entre plusieurs équations intégrales," C. Cailler.

National Geographic Magazine for January; *Washington, D. C.; $2.50 per year, 25 cents a copy:* "Beacons of the Sea; Lighting the Coasts of the United States (with 67 illustrations and chart," George R. Putnam; "The Discovery of Cancer in Plants; An Account of Some Remarkable Experiments by the U. S. Department of Agriculture (with 11 illustrations)"; "From Jerusalem to Aleppo (with 30 illustrations and map)," John D. Whiting; "Honors to Amundsen and Peary (with illustrations)."

Nature-Study Review for February; *School of Education, University of Chicago; $1.00 per year, 15 cents a copy:* "Common Rocks—Third Paper," W. A. Tarr; "Wind-Blown Sand," Geo. J. Miller; "A Trip to the Sand Dunes," Florence Valentine; "Tree Study in Primary Grades," Edith R. Mosher.

Photo Era for March; *383 Boylston St., Boston; $1.50 per year, 15 cents a copy:* "Floral Photography by Artificial Light," Leon Jeanne; "Quick Work," J. N. Jockel; "Architectural Subjects," William S. Davis; "Photographic Home-Amusements." Wilfred A. French; "Soft Prints from Sharp Negatives," Mrs. C. B. Fletcher; "Enlarging with a Box-Camera," Lehman Wendell; "Lamplight-Pictures," Wiener Mitteilungen; "My Photographic Retreat," Claude Davis Millar.

Physical Review for February; *Ithaca, N. Y.; $6.00 per year, 50 cents a copy:* "Some Characteristic Curves for Gases at Low Pressures," Robt.

F. Earhart; "Viscosity and Fluidity—A Summary of Results, II," Eugene C. Bingham; "An Absolute Determination of the Viscosity of Air," Lachlan Gilchrist; "Determination of the Heat of Solution of Metals by Means of a Vacuum Flask Calorimeter," E. E. Somermeier; "The Electron Theory of Phosphorescence," Chester A. Butman; "On the Theory of Relativity; Mass, Force and Energy," R. D. Carmichael.

Popular Astronomy for March; *Northfield, Minn.; $3.00 per year, 15 cents a copy:* "Latest Advances in Weather Forecasting at Long Range by Sunspots and Planetary Positions," Jerome S. Ricard; "Notes on the Periods of Nine Eclipsing Variables," Harlow Shapley; "Total Eclipse of the Moon 1913, March 22," William F. Rigge; "The Solar Eclipse of 1913, April 6, as Visible in the United States," William F. Rigge; "An Amateur's Observatory at West Collingswood, N. J.," H. C. Bancroft, Jr.; "The Story of the Zodiac," Edith R. Wilson.

Psychological Clinic for February; *College Hall, Philadelphia, Pa.; $1.50 per year, 20 cents a copy:* "Individual Differences in School Children," Elmer E. Jones; "Constructive Morals and School Life," Herbert F. Clark; "Causes of Non-Promotion," George L. Farley; "Mental and Physical Examination of School Children in Rural Districts," William H. Pyle.

School Review for February; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "The Distribution of High-School Graduates after Leaving School," Guy-Wheeler Shallies; "The Training of High-School Teachers," Calvin N. Kendall; "The Association of Colleges and Secondary Schools of the Southern States," Chancellor J. H. Kirkland.

School World for February; *Macmillans and Campany, London, Eng.; 7s, 6d per year, 6 pence a copy:* "Attention—The Child's Point of View," J. W. Adamson; "School Natural History Societies," F. W. Headley; "School Scientific Societies," W. M. Hooton; "School Reform in Germany," T. R. Dawes; "The Training of Teachers," J. Welton; "The Co-operation of Employers and Educational Authorities," William Mather; "Apparatus Designed by Science Masters (illustrated)."

Zeitschrift für den Physikalischen und Chemischen Unterricht for January; *Prof. Dr. F. Paske, Berlin-Dahlem, Friedbergstrasse 5, 6 numbers $2.88, M. 12 per year:* "Schülerübungen aus der Mechanik und der Wärmelehre," W. Bahrdt; "Über ein Unterrichtsmodell des periodischen Systems der Elemente," E. Beutel; "Unterrichtsversuche zur Demonstration der Eigenschaften des Wechselstroms," A. Lindemann; "Die Verwendung des Le Chatelier-Pryometers beim Unterricht," Fr. C. G. Müller; "Ein handliches Mikromanometer," K. Schreber. KLEINE MITTEILUNGEN: "Ein Apparat zur Demonstration des Flächensatzes," O. Bartenstein; "Weiteres zur Verwendung des Fahrrades im Physikunterricht," W. Weber; "Versuche mit einfachen Mitteln," R. Danneberg, Verwendung von kleinen Glühlampen zum Nachweis der Widerstandsänderung bei festen und flüssigen Körpern; "Für die Praxis," A. Lesky, Leitfähigkeit von Glas.—I. Kraus, Leucht- und Heizflamme.

Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht for January; *B. G. Teubner, Leipsic, Germany; M. 12 per year:* "Peter Treutlein," Hans Wolfgang Behm; "Der mathematisch-naturwissenschaftliche Unterricht in England," P. Riebesell; "Staatsbürgerliche Erziehung in mathematisch-naturwissenschaftlichen Unterricht," Dr. Laugwitz; "Zur geometrischen Veranschaulichung des Taylorschon Lehrsatzes und ähnlicher Annährungsformeln," Wilhelm Lorey; "Ein Riesenfortschritt in der Schmetterlingskunde," O. Kranscher; "Zur Einführung in die Logarithmen," H. Pfaff; "On the Summation of a Series," I. J. Schwatt; "Zur Reformbewegung auf dem Gebiete des Mathematischen und naturwissenschaftlichen Unterrichts," W. L. Liezmann.

PROBLEM DEPARTMENT.

By. E. L. Brown,
Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott Street, Denver, Colo.

Algebra.

323. *Proposed by Nelson L. Roray, Metuchen, N. J.*

In a series of equal ratios the sum of the mean proportionals of each antecedent to its consequent is equal to the mean proportional between the sum of the antecedents and the sum of the consequents.

I. *Solution by Nelson L. Roray, Metuchen, N. J., and Agnes MacNeish, Chicago, Ill.*

Put $a/b = c/d = e/f = \ . \ . \ . \ = r^2$. Then

$$ab = b^2r^2 \text{ and } \sqrt{ab} = br$$
$$cd = d^2r^2 \qquad \sqrt{cd} = dr$$
$$ef = f^2r^2 \qquad \sqrt{ef} = fr, \text{ etc. Whence}$$
$$\sqrt{ab}+\sqrt{cd}+\sqrt{ef}+ \ . \ . \ . \ = (b+d+f+ \ . \ . \ .)r.$$

Again

$$(a+c+e+ \ . \ . \ .)/(b+d+f+ \ . \ . \ .) = r^2$$
$$(a+c+e+ \ . \ . \ .)(b+d+f+ \ . \ . \ .) = (b+d+f+ \ . \ . \ .)^2r^2$$

Hence $\sqrt{(a+c+e+ \ . \ . \ .)(b+d+f+ \ . \ . \ .)} = (b+d+f+ \ . \ . \ .)r$
$= \sqrt{ab}+\sqrt{cd}+\sqrt{ef}+ \ . \ . \ .$

II. *Solution by John M. Gallagher, Boston, Mass.*

Let $a/b = c/d = e/f =$ $\quad \therefore bc = ad, be = af, de = cf.$

$$\begin{aligned}(a+c+e)(b+d+f) &= ab+ad+af+bc+cd+cf+be+de+ef.\\ &= ab+cd+ef+2ad+2af+2cf.\\ &= ab+cd+ef+2\sqrt{(ad)^2}+2\sqrt{(af)^2}+2\sqrt{(cf)^2}.\\ &= ab+cd+ef+2\sqrt{adbc}+2\sqrt{afbe}+2\sqrt{cfde}.\\ &= [\sqrt{ab}+\sqrt{cd}+\sqrt{ef}]^2.\end{aligned}$$

$$\therefore [(a+c+e)(b+d+f)]^{\frac{1}{2}} = \sqrt{ab}+\sqrt{cd}+\sqrt{ef}.$$

Note: This theorem can be used to find the formula for the volume of the frustum of any pyramid, when the formula for the volume of the frustum of a triangular pyramid is known.

324. *Proposed by Otto J. Ramler, Buffalo, N. Y.*

If ax^2+bx+c and $a'x^2+b'x+c'$ have a common factor of the form $x+f$, prove that

$$(ac'-a'c)^2 = (bc'-b'c)(ab'-a'b).$$

I. *Solution by T. M. Blakslee, Ames, Iowa, and H. C. McMillin, Lawrence, Kansas.*

Dividing and putting each of the remainders equal to zero we have

$$af^2-bf+c = 0 \quad \text{and} \quad a'f^2-b'f+c' = 0$$

Eliminating f $\quad f^2 = (bc'-b'c)/(ab'-a'b)$

Eliminating f^2 $\quad f = (ac'-a'c)/(ab'-a'b)$

Hence $f^2 = (ac'-a'c)^2/(ab'-a'b)^2 = (bc'-b'c)/(ab'-a'b)$,
$(ac'-a'c)^2 = (ab'-a'b)(bc'-b'c)$

II. *Solution by A. H. Hughey, El Paso, Texas, I. L. Winckler, Cleveland, Ohio, and Julia M. Bligh, Batavia, N. Y.*

Factoring each expression we have

$$ax^2+bx+c = a\left(x+\frac{b}{2a}+\frac{\sqrt{b^2-4ac}}{2a}\right)\left(x+\frac{b}{2a}-\frac{\sqrt{b^2-4ac}}{2a}\right)$$

$$a'^2+b'x+c' = a'\left(x+\frac{b'}{2a'}+\frac{\sqrt{b'^2-4a'c'}}{2a'}\right)\left(x+\frac{b'}{2a'}-\frac{\sqrt{b'^2-4a'c'}}{2a'}\right)$$

$$\therefore \frac{b}{2a}+\frac{\sqrt{b^2-4ac}}{2a} = \frac{b'}{2a'}+\frac{\sqrt{b'^2-4a'c'}}{2a'}$$

Reducing we have

$$(ac'-a'c)^2 = (bc'-b'c)(ab'-a'b)$$

III. *Solution by Elmer Schuyler, Brooklyn, N. Y., Walter C. Eells, Tacoma, Wash., and W. J. Risley, Decatur, Ill.*

Using Sylvester's Dialytic Method, we have as the resultant of the two equations the determinant

$$\begin{vmatrix} 0 & a & b & c \\ a & b & c & 0 \\ 0 & a' & b' & c' \\ a' & b' & c' & 0 \end{vmatrix}$$

which must be zero if the equations have a common factor $x+f$. Expanding in terms of determinants of the second order formed from the first two columns.

$$a^2c'^2-aa'cc'+a'^2c^2-(ab'-a'b)(bc'-b'c) = 0$$

Whence $(ac'-a'c)^2 = (bc'-b'c)(ab'-a'b)$.

See Bôcher's Introduction to Higher Algebra, p. 199.

Geometry.

315. Construct a triangle, given its pedal triangle.

NOTE, *by R. M. Mathews, Riverside, Cal.* In the two solutions of this problem published in the February number I notice an omission. The solutions are not unique, for a given triangle can be pedal triangle for four different triangles. If for the given pedal triangle ABC we construct the triangle of excenters XYZ we have one solution. But ABC is pedal triangle for any one of the three other triangles formed by two excenters and the incenter.

325. *Proposed by Levi S. Shively, Mount Morris, Ill.*

Construct a triangle, given its circumcenter, its orthocenter, and the mid-point of one of its medians.

Solution by A. M. Harding, Fayetteville, Ark., H. E. Trefethen, Waterville, Me., and I. L. Winckler, Cleveland, Ohio.

Let P, Q, R be the given points, O the centroid of the required triangle ABC. Then O is in PQ, and PO = OQ/2.

Hence RO = ⅙ the median through RO. For R bisects this median, and O trisects it.

Therefore to construct the triangle; take PO = PQ/3; draw the line AROF, making AR = 3RO, OF = 2RO. A is a vertex of the triangle, F is the mid-point of its side BC. About P with radius AP describe a circle and through F perpendicular to FP draw the chord BC.

326. *Proposed by A. Babbitt, State College, Pa.*

In the triangle ABC find a point O such that the product of the perpendiculars from it upon the sides shall be a maximum.

Solution by A. H. Hughey, El Paso, Tex., Elmer Schuyler, Brooklyn, N. Y., and A. Babbitt, State College, Pa.

Put x, y, z for the several perpendiculars, K = area of ABC. Then $ax+by+cz = 2K$ (a, b, c, K being constant in a given triangle).

Hence $ax \cdot by \cdot cz = abc \cdot xyz =$ a maximum when $ax = by = cz$; that is, $xyz =$ a maximum when $ax/2 = by/2 = cz/2 = K/3$.

To find the point O, draw a parallel to BC at ⅓ the distance from BC to A, also a parallel to AC at ⅓ the distance from AC to B.

These parallels, each cutting off the third of a median, meet in the centroid of the triangle, which is the required point O.

For the areas of triangles on the same base are in the same ratio as their altitudes, and hence area BOC = K/3 = area AOC = area AOB.

327. *Proposed by H. E. Trefethen, Waterville, Me.*

In any given triangle ABC,

(a) Find a point O such that its distances from the sides are proportional to these sides respectively;

(b) Through this point O draw parallels EF to AB, GH to AC, IK to BC, and prove that the points E, G, I, F, H, K are concyclic;

(c) Prove also $HF : EK : GI = a^3 : b^3 : c^3$.

Solution by I. L. Winckler, Cleveland, Ohio, Nelson L. Roray, Metuchen, N. J., and H. E. Trefethen, Waterville, Maine.

(a) Let p_1, p_2, p_3 be the perpendiculars from O on a, b, c, respectively, and h_1, h_2, h_3 the altitudes on these sides.

$$\text{Then } \frac{p_1}{a} = \frac{p_2}{b} = \frac{p_3}{c}. \tag{1}$$

$$\text{Also } p_1a+p_2b+p_3c = ch_3, \tag{2}$$

since each side of this equation is twice the area of ABC.

From (1) and (2)

$$\frac{p_3}{h_3} = \frac{c^2}{a^2+b^2+c^2}. \tag{3}$$

$$\text{Similarly } \frac{p_2}{h_2} = \frac{b^2}{a^2+b^2+c^2}, \tag{4}$$

$$\text{and } \frac{p_1}{h_1} = \frac{a^2}{a^2+b^2+c^2}. \tag{5}$$

Find m the side of a square equivalent to $a^2+b^2+c^2$.

Construct a right triangle with legs equal to m and c and let the altitude on the hypotenuse of this triangle divide it into the segments r and s, r being adjacent to m.

$$\text{Then } \frac{r}{s} = \frac{m^2}{c^2} = \frac{a^2+b^2+c^2}{c^2} = \frac{h_3}{p_3}. \qquad \text{[by (3)]}$$

$\therefore$ p_3 is the fourth proportional to r, s, and h_3.

Similarly p_2 may be constructed and the point O located.

(*b*) From the similar triangles ABC and OGI,

$$\frac{p_3}{h_3} = \frac{GI}{c} = \frac{c^2}{a^2+b^2+c^2}. \qquad \text{[by (3), part (a)]}$$

$$\therefore GI = \frac{c^3}{a^2+b^2+c^2} \tag{6}$$

Similarly $\quad EK = \frac{b^2}{a^2+b^2+c^2}$, (7)

and $HF = \frac{a^2}{a^2+b^2+c^2}$. (8)

Also $\frac{GO}{GI} = \frac{b}{c}$,

from similar triangles OGI and ABC. (9)

From (9) and (6) $GO = \frac{c^2 b}{a^2+b^2+c^2}$.

Similarly $EO = \frac{b^2 c}{a^2+b^2+c^2}$.

$\therefore \frac{EO}{GO} = \frac{b}{c}$, also $\angle EOG = \angle A$.

$\therefore \Delta$ EOG is similar to Δ ABC.

$\therefore \angle OEG = \angle C$ and $\angle EGO = \angle B$.

$\therefore \angle KEO + \angle OEG + \angle OIG = \angle A + \angle B + \angle C$,

or $\angle KEG + \angle OIG = 2$ rt. $\angle$s.

$\therefore$ IGEK is inscriptible.

Similarly GEKH is inscriptible, and therefore the circumference through the points I, G, E, K passes through H. In the same manner it may be shown this circumference passes through F.

$\therefore$ IGEKHF is inscriptible.

(c) from (6), (7) and (8), part (*b*),

$$HF : EK : GI = a^3 : b^3 : c^3.$$

CREDIT FOR SOLUTIONS.

318. Julia M. Bligh. (1)

319. Julia M. Bligh. (1)

320. Julia M. Bligh, H. C. McMillin. (2)

321. Julia M. Bligh. (1)

323. A. Babbitt, T. M. Blakslee, Julia M. Bligh, Walter C. Eells, M. Fendel, John M. Gallagher (2 solutions), A. M. Harding, A. H. Hughey, A. MacNeish, R. M. Mathews, A. L. McCarty, M. E. McGregor, H. C. McMillin, Effie Morse, Otto J. Ramler, Nelson L. Roray, Elizabeth Sargent, Elmer Schuyler, Levi S. Shively, H. E. Trefethen, I. L. Winckler. (22)

324. T. M. Blakslee (2 solutions), Julia M. Bligh, M. Gertrude Buck, Walter C. Eells, John M. Gallagher (2 solutions), A. M. Harding, A. H. Hughey, A. L. McCarty, M. E. MacGregor, Agnes MacNeish, R. M. Mathews, H. C. McMillin, Otto J. Ramler, D. H. Richert, W. J. Risley, Nelson L. Roray, Elizabeth Sargent, Levi S. Shively, Elmer Schuyler, H. E. Trefethen, I. L. Winckler. (23)

325. A. M. Harding, A. H. Hughey, Frank A. Logan, H. C. McMillin, Agnes MacNeish, R. M. Mathews, Nelson L. Roray, Elmer Schuyler, Levi S. Shively, H. E. Trefethen, I. L. Winckler. (11)

326. A. Babbitt, A. H. Hughey, Nelson L. Roray, Elmer Schuyler, H. E. Trefethen, I. L. Winckler. (6)

327. A. H. Hughey, Agnes MacNeish, H. C. McMillin, Nelson L. Roray, Elmer Schuyler, H. E. Trefethen, I. L. Winckler. (7)

Total number of solutions, 74.

PROBLEMS FOR SOLUTION.

Algebra.

339. *Proposed by A. Babbitt, State College, Pa.*
Solve: $4x^4-16x^3+27x^2-21x+9 = 0$.

340. *Proposed by H. E. Trefethen, Waterville, Maine.*
$(\underline{|n-1}\,)^2 > n^{n-2}$. Prove.

Geometry.

341. *Proposed by L. M. S., New York City.*
From the vertex of a triangle draw a line to the base so that it may be a mean proportional between the segments of the base.

342. *Proposed by Ernest B. Lytle, Urbana, Ill.*
To find a point in a plane such that the sum of its distances from two given points on the same side of the plane shall be a minimum.

343. *Proposed by R. L. Clayton, Weatherford, Oklahoma.*
Given, any triangle, ABC, and a point, P, without the triangle. To draw a line through the given point so that it shall bisect the triangle. Prove by elementary geometry.

Trigonometry.

344. *Proposed by Nelson L. Roray, Metuchen, N. J.*
Solve the equation:

$$\sin^{-1}\frac{2a}{1+a^2}+\tan^{-1}\frac{2x}{1-x^2}=\cos^{-1}\frac{1-b^2}{1+b^2}$$

(From Hall & Knight's Elementary Trigonometry.)

SCHOOL SOCIAL CENTERS.

Three hundred and thirty-eight schools in 101 cities of the United States were used as social centers during the past season, according to a report compiled by Clarence Arthur Perry for the Sage Foundation. Officials of the United States Bureau of Education, who have examined the report, declare that it is bound to stimulate interest in this rapidly developing phase of the movement for wider use of the school plant.

Mr. Perry finds that in 44 of the 101 cities social centers were directed by paid workers. New York had 48 such centers and Chicago 16, while Philadelphia, Boston, Columbus, Detroit, Jersey City, Louisville, Rochester, and Trenton are also among the cities included in this list. There is wide variation in the length of the season, from five or six weeks in some localities to the full school term in others. In fact, little uniformity prevails as to what constitutes a social center. Mr. Perry presents in the report a tentative definition of a social center as follows: "A community may be said to have a schoolhouse social center if one of its school buildings is thrown open to the public on one or more fixed nights a week for at least 12 weeks a year, for activities of a social, recreational, or civic character, regularly directed by one or more trained leaders."

The report also presents data on the growing use of school buildings for political meetings. In Cleveland, Ohio, meetings were held

in the schools to discuss the new constitutional provisions that were before the people for adoption. In Jersey City the public schools were opened to partisan political meetings with gratifying results; eight public school auditoriums in New York City were also opened for the same purpose, and in Chicago the assembly halls were employed for political rallies and proved a distinctly popular innovation. Milwaukee, Wis., and Worcester, Mass., are cities where the schools have for some time been used for political meeting places.

LIMESTONE.

More limestone is produced in the United States than any other kind of stone, not excepting granite, and its value is also greater. The value of the limestone output in 1911 was $33,897,362, a decrease of $706,316 from the figures for 1910. The decrease in value was chiefly in limestone used for fluxing. These figures do not include the value of most of the stone that is burned into lime, nor a large quantity of limestone used in the manufacture of Portland cement. The principal states that produced limestone in 1911 were, in rank of value, Pennsylvania, Ohio, Indiana, Illinois, New York and Missouri, each having an output of more than $2,000,000.

HIGHEST AND LOWEST POINTS IN THE WORLD.

The maximum difference in elevation of land in the United States is 14,777 feet, according to the United States Geological Survey. Mount Whitney, the highest point, is 14,501 feet above sea level, and a point in Death Valley is 276 feet below sea level. These two points, which are both in California, are less than 90 miles apart. This difference is small, however, as compared with the figures for Asia. Mount Everest rises 29,002 feet above sea level whereas the shores of the Dead Sea are 1,290 feet below sea level, a total difference in land heights of 30,292 feet. Mount Everest has never been climbed.

The greatest ocean depth yet found is 32,088 feet, at a point about 40 miles north of the island of Mindanao, in the Philippine Islands. The ocean bottom at this point is therefore more than 11½ miles below the summit of Mount Everest.

The difference in the land heights in Europe is about 15,868 feet.

TEACHERS NEEDED IN CHICAGO.

There is at present a great demand for high school teachers in Chicago. This is especially so in the sciences, mathematics and manual training. The rapid growth of the city and the opening of two great new high schools is the cause of this need. Here is a splendid opportunity for teachers, in the subjects named, to get into this big system.

In science the most urgent need is in departments of physics and chemistry. There are now no eligible names on the list, all candidates having received appointments. It probably is not generally known that the maximum salary has recently been raised to $2,600.00. Teachers of considerable experience are now assigned at a very much higher initial salary than formerly.

Examination will undoubtedly be held during the latter part of June. Persons contemplating taking the examinations should write at once for information to the Department of Examinations, 828 Tribune Building, Chicago, Ill.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Readers of School Science and Mathematics *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

104. *Proposed by Miss L. J. Taylor, West Chicago, Ill.*

Which has the more friction to overcome—a train or a boat? Is there a problem to prove it?

Solutions and Answers.

97. *Proposed by C. E. Guffin, Cleveland, Ohio.* (This is an actual problem.)

A load is attached to the axle of a sheave and the whole suspended by means of a rope passed around the sheave so as to divide the load on the rope into two parts. Call that part of the rope on one side of the sheave A and that on the other side B.

The suspended load amounts to 40,000 pounds. With the end of the rope B fixed, what will be the pull at A necessary to lift the load if friction reudces the efficiency to 97.5 per cent. What will be the pull at B?

Solution by S. E. Guffin.

Let x = pull on A.

Let y = pull on B.

$$x+y = 40{,}000 \text{ pounds.}$$
$$y = .975x.$$
$$x = 40{,}0000-.975x.$$
$$1.975x = 40{,}000.$$
$$x = 20{,}253 \text{ pounds.}$$
$$y = 19{,}747 \text{ pounds.}$$

Solution by S. F. Atwood, Dayton, Wash.

The mechanical advantage of this arrangement is 2. Hence the theoretical effort required at A is 20,000 pounds, but, since the efficiency of the system is only 97.5 per cent, 20,000÷.975 = 20,513 pounds, total pull at A. The pull on B = 40,000—20,513 + the amount due to friction in the pulley.

[Why are the results different and which is correct?]

Mr. Atwood says: "I think the difference in results between Mr. Guffin and myself is due to a different interpretation of efficiency. My conception of efficiency is the ratio of the total load to the effort and not the ratio between the pulls on the two cords."

[The following was sent in answer to Question 86 of this department.—Ed.]

Why give a laboratory examination similar to that given by Harvard University? What can an examiner find out by such an examination? In what ways can the examination benefit (1) the pupil; (2) the teacher?

In answer to your inquiry concerning the merits of the Harvard laboratory admission examinations in science, we, as three members of the Department of Physics who have had experience in these examinations, make the following statement of the matter as it appears to us:

There is a very strong family resemblance among all the physics laboratory notebooks from any one school, so that a laboratory test is almost necessary to show which candidates have done the experiments intelli-

gently and which ones have more or less mechanically followed directions.

The laboratory test, which is accompanied by oral questions, is elastic in range and duration. It gives the slow but sure boy the time he needs to do himself justice, and it enables the examiners to try out doubtful cases. It is, therefore, more satisfactory, on the whole, than the written examinations.

School teachers who are familiar with the working of our laboratory examination approve of it and have urged men outside New England to advocate such a test in connection with the examinations of the College Entrance Board.

Very truly yours,

Jefferson Physical Laboratory,
Harvard University,
Cambridge, Mass.

EDWIN H. HALL.
HARVEY N. DAVIS.
G. W. PIERCE.

SCHOOL DISEASES.

Children of school age contract such diseases as measles, scarlet fever and diphtheria much more frequently than older persons. All that has been learned about the modes of transmission of certain diseases, notably diphtheria, indicates that the taking of a large number of children out from their restricted family and neighborhood relationships and bringing them into contact with a much larger group will increase the opportunities for infection. As regards opportunities for infection furnished by the school, it must be admitted that while the slate, the common drinking-cup and the roller-towel are fast passing away, sufficient facilities for the transfer of disease germs still exist in the friendly exchange of pocket handkerchiefs, lip-moistened lead-pencils, chewing-gum and the like. The school playground, as well as the schoolroom, must be considered in its bearing on the subject of school diseases. The significance of school attendance on the public health side lies not only in the assembling of children in a room, but also in the bringing into more or less intimate association a number of children who would otherwise not have met at all. Increasing the number of associates must necessarily increase the chances of infection. Diphtheria and scarlet fever show a marked increase in the autumn when the schools open and an equally definite decrease in the summer when the schools are closed.

The discovery of the part played by the healthy germ-carrier throws light on the probable origin of certain obscure cases of infection, says Prof. E. O. Jordan of the University of Chicago in a recent issue of *The Journal of the American Medical Association*. A child in a family in which a case of diphtheria exists may bear in its throat living diphtheria bacilli without manifesting any sign of disease. If this child is allowed to enter school a playmate may acquire the bacillus without in its turn becoming definitely ill. This second child, however, may take the germ home and pass it on to a non-school-going child in the same family who then may develop a typical case of diphtheria. Methods of control of school and institutional outbreaks of diphtheria are therefore coming to be focused on the detection and exclusion of the carrier. Disinfection of innocent chairs and tables and enforced school closure are in general found to be less effective than the discovery and isolation of the living bearer of diphtheria germs. When school attendance is regulated by bacteriologic findings school epidemics quickly subside.

IOWA STATE SUMMER SCHOOL.

This coming summer Iowa will open its $2,500,000 state college of agriculture and the mechanic arts at Ames to teachers who want to fit themselves for teaching agriculture, home economics or manual training. Last year's experiment with a six weeks' session was so much of a success that the state board of education voted unanimously to make it permanent.

Two lines of instruction will be offered; there will be general courses in agriculture, home economics and manual training for those who want to equip themselves for teaching these subjects in rural or secondary schools, and there will be courses of college grade for those who want to do special work for college credit. The state superintendent of schools in Iowa is urging high schools which are getting state aid for courses in agriculture and home economics to send their special teachers to this summer session. The six weeks' work will begin June 16th and end July 25th. Because the state is back of the work, the fees will be small. The instructors will be chosen from the college faculty and the entire college equipment will be available.

BOOKS RECEIVED.

The Electric Motor and Its Practical Operation. By Elmer E. Burns, Medill High School, Chicago. 191 pages. 13 x 19 cm. 78 figures. 1912. Cloth. $1.50. The Joseph G. Branch Publishing Co., Chicago.

Text-Book of Mathematics and Mechanics. By Charles A. A. Capito. Pages xv+398. 14 x 19 cm. 174 figures. 1913. Cloth. $4.00, net. J. B. Lippincott Company, Philadelphia.

Higher Algebra. By Herbert E. Hawkes, Columbia University. Pages v+222. 14 x 21 cm. 1913. Cloth. Ginn and Company, Boston.

Heat. By J. A. Randall, Pratt Institute, Brooklyn. Pages xiv+331. 80 figures. 14 x 19 cm. 1913. Cloth. $1.50, net. John Wiley and Sons, New York.

Essentials of Electricity. By W. H. Trinbie, Wentworth Institute, Boston. Pages xiii+271. 12 x 17 cm. 1913. Cloth. John Wiley and Sons, New York.

Industrial Mathematics. By Horace W. Marsh, Pratt Institute. Pages viii+477. 227 figures. 14 x 21 cm. 1913. Cloth. $2.00, net. John Wiley and Sons, New York.

Elementary Principles of Electricity and Magnetism. By Robert H. Hough and Walter M. Boehm, University of Pennsylvania. Pages vii+233. 13 x 19 cm. 1913. Cloth. $1.10, net. MacMillan and Company, New York.

Report of the State Superintendent of Public Instruction of Kansas. 388 pages. 15 x 22 cm. 1912. Paper. State Printer, Topeka.

Report of Board of Education of Kansas City, Mo. 343 pages. 15 x 21 cm. 1912. Paper. Tingle-Lufts Co.

Proceedings of the Fourth Annual Convention of the Saskatchewan Educational Association. 149 pages. 15 x 24 cm. 1912. Paper.

Elements of Plane Trigonometry. By Robert E. Moritz, University of Washington. Pages viii+224+91. 14 x 21 cm. 1912. Cloth. John Wiley and Sons, New York.

Achievements of Chemical Science. By James C. Philip, Imperial College of Science and Technology, London. Pages vi+217. 12 x 18 cm. 1913. Cloth. 60 cents, net. MacMillan and Company, New York.

Elementary Biology, Plant, Animal, Human. By James Edward Peabody, Morris High School, New York, and Arthur Ellsworth Hunt, Manual Training High School, Brooklyn. Pages xxi+229. 14 x 19 cm. 1913. Cloth. $1.25, net. MacMillan and Company, New York.

BOOK REVIEWS.

Practical Mathematics. Part III. Algebra, by C. I. Palmer, Assistant Professor of Mathematics, Armour Institute of Technology. Pages xi + 178. 12 × 18 cm. Price, 75 cents. 1913. McGraw-Hill Book Company, New York.

Algebra is presented in this book as the continuation of arithmetic. The use of letters in stating principles and rules briefly and clearly as formulas is well developed, and the necessity of learning to derive and manipulate formulas is emphasized. In order to handle equations readily the necessary work in the fundamental operations, factoring, fractions, and exponents is given.

Though the book was written primarily for classes in evening and trade schools it would serve as an excellent basis for work in algebra in high school. Indeed a thorough mastery of this book would give a sufficient preparation for further work in mathematics. The explanations are clear, the exercises for drill in manipulation are well chosen, and the problems have a basis in real things and a connection with real life.

H. E. C.

Experimental and Theoretical Geometry, by A. T. Warren, M. A., Second Master at the William Ellis Endowed School, N. W. Pages viii + 294. 14 × 19 cm. Price, 2s. Third Edition. 1905. The Clarendon Press, Oxford.

The work in geometry is divided into two courses. In the first 100 pages the pupil is taught to draw conclusions for himself while constructing his figures and solving problems by the use of squared paper, protractor, set squares, rule, and compasses.

In the theoretical course the author has aimed to make the proof of every theorem complete in itself as far as possible, to make the proof depend upon as few principles as possible, and to avoid the indirect method of proof. Methods of proof depending on the folding of the figure about a line, or on rotation in the plane of the figure about a point are largely used. There are many excellent features in this book, though it is purely a geometrical text book.

H. E. C.

Junior Mathematics, by David B. Mair, Author of "A School Course of Mathematics." Pages vii + 200. 13 × 19 cm. Price, 2s. 1911. The Clarendon Press, Oxford.

An introduction to geometry and algebra is offered by the work outlined in this book. In geometry it includes an elementary treatment of angles, triangles, circles, parallels, and mensuration. No formal proofs are given. The pupil is aided in reasoning out proofs for himself by working out exercises and problems. A large number of rather easy exercises are arranged to lead up to the properties of geometrical figures to the various facts of geometry.

There is no formal work in algebra in the book. The rather small amount of algebra is included in the construction and evaluation of formulas and in making graphs. A number of English textbooks like this should be in the library of every teacher of algebra and geometry. A study of these books will help us in our attempts to improve the teaching of mathematics.

H. E. C.

Elementary Trigonometry, by W. E. Paterson, Mathematical Master, Mercer's School. Pages 204 + 44. 13 x 19 cm. Price, 2s., 6d. 1911. The Clarendon Press, Oxford.

During the last five years nearly a dozen textbooks in trigonometry have been published in America. For the most part these texts treat the subject as if the only purpose of trigonometry was to solve triangles, and most of the practical problems lead to the solution of triangles. This book and some other English texts show that it is possible not only to make a course in trigonometry serve as an important review of geometry, but also to make it reach forward into the beginnings of analytic geometry. Moreover, they reveal many important applications of angle functions in physics, mechanics, engineering, and so on.

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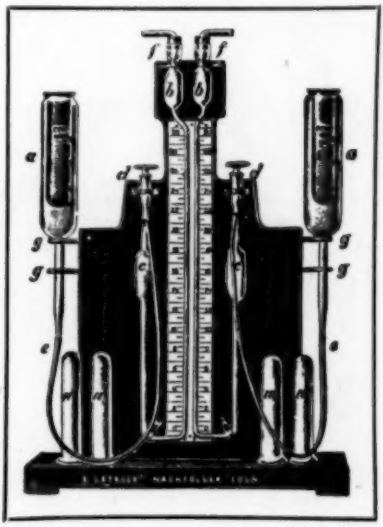

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The present volume deserves a careful examination by instructors in trigonometry. The large number of oral exercises, the use of squared paper, the chapter on vectors, the large number of examples for a review of the fundamental principles of trigonometry together with the application of theorems of geometry and the problems which establish a connection with analytic geometry, are some of the distinguishing features. The large number of examples, nearly 1,000, allow a wide choice for the needs of different classes. H. E. C.

Field and Laboratory Guide Part I. Principles of Economic Zoölogy, by L. S. Daugherty, M. S., Ph. D., Professor of Zoölogy, State Normal School, Kirksville, Mo., and M. C. Daugherty, Kirksville, Mo. Pages vi + 276. 14 × 21 cm. 1912. Cloth, $1.25 net. Philadelphia and London: W. B. Saunders Company.

This book was written to accompany the author's "Principles of Economic Zoölogy." It is unusual in several respects. Fewer directions are given than is usual in most manuals, but dependence is placed upon numerous questions, brief questions, many of them consisting of a single word followed by a question mark covering every phase of the laboratory or field study of each animal. The author has also evolved a system of general studies which are to apply to any animal—the student selecting those questions pertinent to the animal in hand. Besides this there are special questions for each animal. At the beginning of each study there are brief directions as to what questions to take for the ensuing study. Here are the directions for the study of "Pisces (the fish)":

"Take the study of a live fish. Take all applicable points of general studies I, II, III. Take special morphophysiologic study. Take systematic study for branch Chordata and class Pisces. Take final study (a general study). Give your best definition of a fish. Make an oral recitation of ten minutes on fishes. Write a theme on the fish, using, in connected form, the facts you have gathered in your studies. Illustrate with good sketches."

It will be seen from the above that the study is very comprehensive beginning with collecting the live fish and ending with the systematic classification of the animal. Studies of behavior and physiological relations are quite complete. The entire plan is unique. How it works with classes can only be guessed at without actual trial. Doubtless the work could be handled successfully by pupils of some maturity, such as are found in normal schools and freshman classes of college. W. W.

Essentials of Chemistry by J. C. Hessler and A. L. Smith. Revised edition (1912) by J. C. Hessler. Pages 505+xxviii+121. Benj. H. Sanborn & Co., New York and Chicago.

The first edition of this text book met with great and deserved success. This edition is the outcome of the author's experience during the past ten years.

The book has been entirely rewritten. The cuts are all new. Its aim is to present the subject from the chemical point of view. In this the author has been very successful. The most important changes are: The theoretical matter has been presented earlier than in the first edition; the gas laws are given in chapter III; the law of definite proportions and equivalent weights are given in the chapter (V) on water. Chapters VII, VIII, XI, XII and XIII treat of the other fundamental laws and calculations of problems.

Equilibrium and mass action are given a separate chapter. The chapter on ionization gives a full and satisfactory discussion. The "nascent state" is ascribed to the presence of catalyzers or excessive amounts of energy.

The laboratory manual which is bound together with the text contains 87 well chosen and well written experiments.

The directions are very clear and so written that the pupil will require very little help from the teacher. C. M. T.

Laboratory Books in Botany

Bergen and Davis: A Laboratory and Field Manual of Botany, 257 pages, 90 cents.
Containing full directions for laboratory and field work, numerous experiments in plant physiology, and accurate studies of the different types of spore plants. The book deals also with the quantitative study of plant adaptations.

Clute: Laboratory Botany, 177 pages, 75 cents.
An invaluable manual for the busy teacher or independent student. Clear outlines of the specific subjects, lists of definite questions, and a glossary of difficult terms in each section are helpful features of the work.

Meier: Plant Study, in Biflex Binder, 75 cents.
Perhaps the first book of its sort to serve the double purpose of notebook and herbarium. It contains 36 plant studies with space for drawings, 18 sheets for notes, and 10 sheets for describing and preserving specimens.

Meier: Herbarium and Plant Description, 60 cents; in Biflex Binder, 65 cents.
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BOSTON **NEW YORK** **CHICAGO**

The Electric Motor and Its Practical Operations, by Elmer E. Burns, Medill High School, Chicago. 191 pages. 13 x 19 cm. 78 figures. 1912. Cloth. $1.50. The Joseph G. Branch Publishing Co., Chicago.

It surely is a pleasure to say a few words in commendation of this book. It is one which deals primarily with the fundamental principles of the electric motor, in such a clear and concise manner that any person, with ordinary intelligence, cannot help but understand its statements after careful reading and study. No better book is written for use with classes studying the dynamo and motor. It is peculiarly adapted for third semester work for boys in electricity. No extended knowledge of mathematics is required for an understanding of the matter here treated. Not only is the book excellent for class work, but it is just as valuable to the layman or engineer who wishes to, or must receive independently of others, a good, practical working knowledge of the electric motor. It treats of all phases of the motor, from the very simplest forms to the most efficient kind now in use. There are fourteen chapters, each discussing a particular side of the work. There is a valuable appendix of 13 pages giving the horse-power required to drive various machines. There is a complete index. Schools will make no mistake in adopting it for use. C. H. S.

A Laboratory Manual of Agriculture for Secondary Schools, by Call & Schafer. Pages 344. 13 x 19 cm. 1912. 90¢ net. Macmillan, New York.

The present interest in elementary instruction in agriculture is bringing out many new books. The present book is by authors living in the Mississippi Valley and represents the practice in that part of the country. Blank pages intended for laboratory notes are interleaved.

Teachers of agriculture will be interested in the book, and many of the exercises might well be adopted by teachers of botany also. It would be too much to say of any book that is written to meet so new a situation as that which is represented by high school agriculture, that the book exactly fits the needs. We do not yet know precisely what the needs are. This book will be found serviceable in the laboratory and will assist in fixing opinion with regard to appropriate exercises.

The eighty-two topics are arranged in season order and this may be unfortunate in that it renders proper correlation of the laboratory work with any text book very difficult. W. L. E.

Elementary Entomology, by E. Dwight Sanderson, Dean of the College of Agriculture, West Virginia University, and C. F. Jackson, Professor of Zoölogy and Entomology, New Hampshire College. Size 14×20 cm. Pages vii+372, Ginn and Company. 1912.

This book is intended for students in colleges and universities beginning the study of entomology. It should be very useful to teachers of zoölogy in high and normal schools as a reference book. It consists of three parts: I. "The Structure and Growth of Insects"; II. "The Classes of Insects"; III. "Laboratory Exercises." There are also keys to the orders and families of insects, chapters on collecting and preserving insects and reference lists of dealers in entomological supplies, state agricultural experiment stations and state entomologists and of books useful to the student of entomology.

It would be difficult to say too much in praise of this book. The mechanical make-up of the books is excellent, but the work of the authors is better still. The illustrations are very plentiful—there are 496 figures—and well chosen and executed. It will be a very welcome book to teachers who wish a more convenient and accessible reference book than the manuals of entomology heretofore available. W. W.